# SYLLABUS for course ASTB23 Stars, Galaxies & the Universe
Fall 2018. The contents may slightly change as we go, and the syllabus updated.

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Lectures: Thursdays 12:00-14:00 AA206. Tutorials: Thur. 17:00-18:00 AA206,
(NOTICE: no tutorial after the first meeting!)
Calendar od lectures (L1...L24) and tutorials (T1...T10) with remarks:

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 6 Sept.        L1 + L2,       --
13 Sept.        L3 + L4,       T1       (last day to add/remove courses is 18 Sept)
20 Sept.        L5 + L6,       T2
27 Sept         L7 + L8,       T3      <-- assignment set 1 due
 4 Oct.         L9 + L10,      T4
11 - no meetings, reading week
18 Oct.        L11 + L12,      T5      <-- assig. set 2 & in-class midterm during T5
25 Oct.         L13 + L14,     T6
 1 Nov          L15 + L16,     T7
 8 Nov.         L17 + L18,     T8      <-- assign. set 3 due
15 Nov.        L19 + L20,      --      (last day to drop courses w/o pen. is 19 Nov)
22 Nov.         L21 + L22,     T9
29 Nov.         L23 + L24,     T10     <-- assign. set 4 due
?? Dec,                                 <--- final exam
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[2 double-sided hand written sheets (not printed or photocopied), i.e. 4 pages of own notes are allowed at midterm, and 3 sheets (6p.) during the final exam.
Calculators are required. Books, phones, electronic devices not allowed.]

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Office hours: right after lectures, right after tutorial; other times as well, stop by and ask if you can talk to me.

Note: The updates to this syllabus will be available via link to course web page: http://planets.utsc.utoronto.ca/~pawel/ASTB23
Topic number below does not necessarily coincide with lecture number.
In order to know "where we are" at present, make note of it at the end of each lecture. See web page for textbooks. In the second part of the course the provided PDF lecture notes will be important.
The relevant chapters/sections of the textbook #3 are indicated as, for instance, Chapter 5.1, => [5.1], while [L10] would indicate Lecture10 in PDF/PPT form, posted on our web page

0. Organization and goals of the course

1. Introduction to stellar (and planetary) astrophysics [L1]

* Unification of planetary sciences, connections w/physics
* Comments on the history of the idea of other stars and planets

2. The Present Revolution in Astronomy: An Overview
[1-Unnumbered] From p. xvii of textbook 1.
PLEASE READ - it's a very good overview, we skipped it during the lecture as it is indeed long, but you should read the whole 150+ page textbook, and one or two questions from this overview may be asked on the quiz, a prefect example may be Hubble law.

Until the midtem, we will follow closely our textbook 1 ("What are the stars")

1. What are the Stars?
    * Historical Introduction
    * The Photosphere
    * The Interior of the Sun
    * The Virial Theorem
2. Stars as Globes of Gas
    * A Theory of the Stars
    * Hydrostatic Equilibrium
    * Why Does the Sun Shine?
    * Source of Energy
3. Eddington's Theory of the Stars
    * Radiation Pressure
    * Radiative Equilibrium
    * Basic Equations of Stellar Structure
    * Solution of the Equations of Stellar Structure
    * Eddington's Mass-Luminosity Relation
    * The Eddington Luminosity Limit
5. Energy Generation in the Stars
    * The Hypothesis of Nuclear Fusion in the Stars
    * The Basic Difficulty
    * Tunnelling Through a Potential Barrier
    * The Neutron and the Neutrino
    * The Synthesis of Helium in the Stars
    * Why Does the Sun Not Blow Itself Up?
6. Sounds of the Sun
    * The Standard Model of the Sun
    * The Phenomenon of Convection
    * Sounds of the Sun
    * Nodes, Nodal Lines and Nodal Surfaces
    * Vibrating Spheres
    * Helioseismology
    * The Antarctic
    * The Standard Model Put to Test
    * Rotation of the Sun from Helioseismology
7. The Smoking Gun is Finally Found
    * The Hunt for the Smoking Gun
    * The Kamiokande II Experiment & The Atmospheric Neutrinos
    * The Sudbury Neutrino Observatory
    * Neutrinos Do Oscillate in Flavour

Book 2:
8 2. Stars in Their Youth
    * H-R diagram p. 15

* Energy Generation in the Main Sequence 17
* Conection in Stars 20
* The Lifetime of Stars 21
* The Ultimate Fate of the Stars 23

9 3. White Dwarf Stars p. 25
* The Strange Companion of Sirius 25
* Gravitational Redshift 27
* A Stellar Paradox: Have the Stars Enough Energy to Cool? .

10 5. Fermi-Dirac Distribution 55
* Pauli's Exclusion Principle 55
* The Fermi-Dirac Distribution 56
* Pressure laws of the Degenerate Electron Gas 58
* Fermi Momentum 60

11 6. Quantum Stars 67
* Fowler and Chandra 67
* Chandrasekhar's Theory of the White Dwarfs 71
* All Stars will Ultimately Find Peace 77

12 7. The Chandrasekhar Limit 79
* Relativistic Stars 79
* Chandrasekhar limit 84
* Can All Stars Find Peace? 90

The 2nd part: Sparke and Gallagher book "Galaxies in the Universe"

13. Formation of disks and stars
  * Giant molecular clouds
  * Jeans instability of protostellar cloud cores
  * Opacity-limited fragmentation
  * Simulations: the ubiquity of protostellar disks, brown dwarfs

  Accretion disks [9]
  * AGN and quasars: accretion onto `black' holes
  * Accretion disk geometry
  * Disks as evolving, shearing flows
  * Collapse simulations using SPH (smoothed particle hydrodynamics)

14. Introduction, The Milky Way [1]
  [1.a] History of the discovery of the Galaxy
  [1.b] The Great Debate about galaxies
  [1.1] The stars
  [1.2] Our Milky Way

15. [1.3] Other galaxies, Galaxy photometry
  Hubble sequence, other classifications
  [1.4] Galaxies
  Typical properties and statistics of of galaxies
  Gauss theorem and examples of its use. Laplace equation
  Gravity force and potential
  Spherical systems & Newton's theorems
  Potentials of some simple systems
  Potential- density pairs of flattened systems

16. [2] Mapping our Milky Way
  [2.1] The solar neighborhood 2.2 The stars in the Galaxy
  The vertical structure of the disk / Distances to star clusters /
  Bottliger diagram, asymmetric drift

17. [2.3] Galactic rotation
    Infrared & radio view of the Milky Way
    Glactic bulge and Center (Nucleus)
    Measuring the Galactic rotation curve

18. Relaxation and evolution, part I
    [3] The orbits of stars
    [3.2] Why the Galaxy isn't bumpy: two-body relaxation, encounters
    Relaxation time: theory and the inferred histogram for globular clusters

19. Relaxation and evolution, part II
    The virial theorem / Evaporation / mass segregation
    Effects of two-body relaxation: core collapse of globular clusters
    [3.x] Angular momentum and energy conservation in stellar motion
    Epicyclic theory of orbits in galactic potentials
    epicyclic frequecy, vertical frequency, azimuthal frequency
    and the corresponding periods

20. [4] Our backyard: the Local Group
    [4.2] Spirals of the Local Group
    The Andromeda galaxy / M33: a late-type spiral
    [5] Spiral and S0 galaxies
    [5.3] Gas motions and the masses of disk galaxies

21. Rotation Curves and Spiral Arms in Galaxies
    Decomposition of rotation curves. Two types of rotation curves.
    Dark matter in disk galaxies
    The Tully-Fisher versus the Faber-Jackson relationship
    [5.4] Spiral arms and galactic bars
    Observed spiral patterns: trailing vs. leading spirals
    Disk Dynamics and Spiral Structure
    Dispersion relation for gaseous disks
    Long waves / Short waves / Toomre stability of disks
    SWING amplifier
    Lin-Shu theory of spiral modes and WASER cycle
    Correlation of rotation curve with the type of spiral pattern:
    physical explanation of spiral galaxy classification

22. Bars as a by-product of spiral mode evolution
    Encounters and mergers between galaxies
    Gravitational lensing

23. [6] Elliptical galaxies
    [6.2] Motions of the stars
    The Faber-Jackson vs. Tully-Fisher relations
    [6.5] Galaxy clusters: the domain of elliptical galaxies
    Elliptical galaxies: nature, nurture, or merger?
    [8]Supermassive Black Holes and Active Galactic Nuclei
    early history of galaxies

24. The Universe
    [7] Large-scale distribution of galaxies
    [7.1] Observations of large-scale structure: galaxy clustering
    [7.2] Expansion of a homogeneous Universe
    [7.3] Growth of structure: peculiar motions
    clusters, walls, and voids

[8.3] Cosmic Microwave Background Radiation (CMBR) - satellite observations.

First observational proof of a flat spacetime in our universe:
Boomerag and WMAP experiments

The universe in 21st century:
Einstein's cosmological constant Lambda returns (Dark Energy)