Astr3130 – Spring 2016
Midterm Review

The midterm exam will be an in-class exam and will cover the material through Tuesday March 22. The lecture notes and associated readings can be found on the Course Topics and Schedule page. The exam will take place Thursday March 24. The evening sessions on March 22 and 23 will be focused on exam review and preparation. Expect a mix of conceptual questions and relatively simple quantitative problems (the quantitative problem on the most recent day assignments being representative of the more difficult quantitative questions you might encounter on the test). You may bring along your own original handwritten notes made specifically for the exam (you may not use notes taken in class for this purpose). Since the course powerpoint slides are largely talking points and thus sparse it is likely that you'll be most effective studying in parallel with the readings, reconstructing details discussed in class from the text. The texts typically don't perfectly align with the course material. Seek out the matches and focus on the textbook material directly supporting the in-class discussion. Chromey, in particular, is a higher level text and often goes into much more detail than the expectations for the course, nevertheless when Chromey directly addresses course topics the match is pretty good.

What follows is a sampling of topics of note to prompt your preparation:

Start with the basics. Know how to use the right number of significant figures. Know how that propagate uncertainties. Understand the difference between the standard deviation of a distribution and the standard deviation of the mean. Guides to all these subjects are included on the course home page.

Be able to define and possibly illustrate celestial sphere terminology including: great circle, small circle, zenith, nadir, zenith angle, altitude, azimuth, meridian, hour angle, equator, ecliptic, etc.
Understand how R.A. and Declination tie into these coordinates. What determines the “prime meridian” of R.A.? Explain why cos(dec) matters when generating the distance between 2 points on the celestial sphere.

How is airmass calculated in relation to altitude or zenith angle? Be able to make crude estimates of altitude (and corresponding airmass) for combinations of R.A., sidereal time (and thus hour angle), and declination. Also have the exact formula handy to do the calculation. Be able to make a simple exact measurement of airmass if the source turns out to lie on The Meridian or if your target turns out to be the north celestial pole.

For a given latitude what is the minimum declination for which stars are circumpolar? How, qualitatively, do stars behave during the night at different declinations? What do airmass curves look like for stars at different declination (from latitude +38) – near the pole? on the equator? Dec=-35?

Understand and be able to illustrate why there is a ~4 minute difference between the sidereal and solar day. On what day of the year does your sidereal and solar clock read the same time? Knowing this how can you estimate the sidereal time / solar time difference for any day of the year? What is the relationship between sidereal time, R.A., and hour angle? What’s the use of a transit telescope? Be able to describe how to calculate the current local sidereal time.

What's the difference between mean and apparent solar time? How does the “equation of time” fit into that answer? How many minutes offset can one be from the other. Which one does a sundial measure? What is TAI? UTC? UT1? How do leap seconds fit into these? Know the basics of Julian date and
the difference between Julian Date and Modified Julian Date.

What factors influence the apparent setting time of the Sun? What definitions are there for the various manifestations of twilight? What is the Belt of Venus? What factors contribute to the brightness of the night sky? How does the full moon degrade sky brightness? How much brighter is full moon than half phase? How does this degradation depend on wavelength? Know the approximate rising and setting times of the Moon as a function of phase so that you can parse a night into dark and bright time.

What effect does precession have on the R.A. and Dec of a star vs. timescale? How much can the declination of a star change in 13,000 years?

What causes the aberration of starlight? What is the magnitude of this effect in arcseconds? How does aberration affect the R.A. and Dec of a star? How important is atmospheric refraction relative to aberration in shifting the apparent position of a star? Does refraction move the star toward or away from the horizon? Can you sketch why? What are the effects of refraction on stellar position? How does refraction depend on color? What is parallactic angle? Why is it important in the context of refraction? What is the “green flash”?

What are the fundamental differences and advantages of equatorial vs. alt-azimuth mounts? How do the two mounts differ in behavior regarding field rotation/parallactic angle? At what declination can the parallactic angle change so quickly at some point during the night that it can be a challenge for a telescope control system? Be able to sketch the ray paths in a Cassegrain reflecting telescope. How do you calculate the final focal position of a compound optical system like a Cassegrain telescope? What is a Serrurier truss? What is a “preload” and why is it necessary?

How does a pinhole camera make clear that single lenses produce inverted images? Can you sketch image formation by a lens by tracing a few select rays (keeping track of the fact that the ray through the center of the lens is undeviated by refraction and that a ray parallel to the lens' optical axis must pass through the focal point one focal length away from the lens)? Know Snell's law and the Lensmaker's equation. What is the “focal length” of a lens and how do you find it if someone hands you a lens? What is the focal length of a mirror based on its radius of curvature? What exactly is meant by “radius of curvature”? How does a Barlow Lens increase the magnification of a telescope? What is chromatic aberration and how is it related to the thin lens equation? How do you minimize chromatic aberration? What is spherical aberration? Is it wavelength dependent?

How is focal length related to platescale? How do you determine the magnification of a telescope given a particular eyepiece focal length? Why are the world's largest telescopes reflectors?

How does limiting magnitude scale with telescope aperture? If a 10 cm telescope has a limiting magnitude of 12 for a particular observation how large an aperture will you need to reach a limiting magnitude of 17?

Know the basics of Airy patterns, the Rayleigh criterion, full width at half maximum of the Airy pattern (FWHM), angular distance to the first null, angular distance to the first ring peak – all in terms of lambda/D.

Understand the basics of Poisson statistics and deriving signal-to-noise ratio (SNR). How does background degrade signal-to-noise? Why does this degradation argue strongly for making a star image as sharp as possible on your detector (or said alternatively, minimizing the number of pixels being analyzed to determine the stellar flux)? What does it mean both conceptually and in terms of the
equations to be source photon, background, or read noise limited?

Understand the details connecting $r_0$ and seeing. How does the size of the seeing blur depend on $r_0$? How about the timescale for the seeing speckle pattern to change? What are the speckles? How does $r_0$, and thus seeing, scale with wavelength? What is lucky imaging? What is the Strehl ratio? In general terms, how does adaptive optics work? How can seeing be controlled at an astronomical site? What's the motivation for developing laser guide stars?

Why do solid state detector materials have a “cutoff” wavelength? Be able to calculate this cutoff for a given bandgap in electron volts. How is dark current in a detector related to the bandgap and temperature?

When you make a measurement for a CCD pixel how does the number recorded in analog-to-digital units (ADU) for a pixel relate to the number of photons actually converted into electrons? What is meant by “gain” for an imaging device and how do you calculate it? What is read noise and how does it combine quantitatively with source and background Poisson noise to establish the signal-to-noise ratio of an observation? What does “quantum efficiency” refer to. What measured can be taken to improve quantum efficiency at red or blue wavelengths?

Describe qualitatively how a CCD gets read out. Be able to calculate how long it takes to read out a CCD knowing the pixel readout (pixel dwell) time. Be able explain the concepts of pixel saturation and linearity. What is the purpose of taking a flat field frame? A bias frame? A dark frame? How do you obtain flat field data in practice? What is “charge transfer efficiency” on a CCD? Why does this efficiency have to be nearly perfect (CTE very close to 1)? Why might the median be preferred over the mean when stacking frames? Be able to describe the process of extracting the flux of a star using aperture photometry and the importance of/guidelines for selecting the right size for the star aperture and the right radii for the sky annulus.