Key Concepts and Formulae

Sky Familiarity:
Where and when to observe each of the naked-eye planets.
Lunar phase, location and times of moonrise and moonset.
Constellations, stars and extended objects as identified in the Course Outline

The Sun:
Studying the sun as a star, the advantages and disadvantages of nearness, characteristics of the sun.
Modeling the sun: solar structure, the assumptions of hydrostatic and thermal equilibrium, the modes of energy transport, the solar composition.
The solar energy sources: gravitational contraction, fusion: the proton-proton chain, the CNO cycle,
Regions and features of the solar atmosphere:
The photosphere: quiet features: granules and limb darkening; active features: sunspots and plages.
The chromosphere: quiet features: spicules and supergranules; active features: prominences (filaments) and flares.
The corona: coronal holes.
Solar activity. the 11-yr sunspot and 22-yr activity cycles, magnetic field role, rules and reversals, the Maunder minimum, the butterfly diagram, terrestrial effects of solar activity.
Solar rotation, solar wind.

The Stars:
Stellar parallax and distances, apparent and absolute magnitudes, the magnitude scale (see below), the non-representative sample of naked-eye stars.
Stellar colors and color indices, spectral types, the spectral sequence OBAFGKM and its relation to color and temperature.
The H-R diagram, the main sequence and the minor sequences, luminosity classes, the sizes of stars, the solar spectral-luminosity class.
Binary stars, optical versus physical pairs, visual, astrometric, spectrum, and spectroscopic binaries, the frequency of occurrence of binaries.
Binaries and stellar masses. velocity curves, the stellar mass-luminosity relation.
Eclipsing binaries, light curves.
Binary evolution, Roche lobes, mass transfer, detached, semi-detached, and contact binaries.
Examples of binaries among prominent stars.

<table>
<thead>
<tr>
<th>Δm</th>
<th>Implies $F_1/F_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.512</td>
</tr>
<tr>
<td>2</td>
<td>6.31</td>
</tr>
<tr>
<td>3</td>
<td>15.85</td>
</tr>
<tr>
<td>4</td>
<td>39.8</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>10 000</td>
</tr>
<tr>
<td>15</td>
<td>1 000 000</td>
</tr>
</tbody>
</table>

$\Delta m = 1/p''$, $Flux \propto 1/r^2$ (the inverse square law), $P^2 \text{[yrs]} = a^3 \text{[a.u.]}/(M_1 + M_2)M_\odot$ (Kepler's 3rd law)
$L \propto M^{3.8}$ (Mass-luminosity relation)
Star Formation and the Evolution of Low-Mass Stars:
The interstellar medium: emission nebulae (H II regions), dark nebulae (Barnard objects, globules and elephant trunks), reflection nebulae, giant molecular clouds.
Protostar formation, triggering mechanisms for star formation: density waves, supernovae explosions, hot-star radiation pressure, cloud collisions, cooling by infrared emission; the H-R diagram tracks of forming stars, mass and formation times.
Brown dwarfs, T Tauri variables stars.
The challenges and tools for studying stellar evolution: star clusters and their H-R diagrams.
The solar age, lifetime, history, current evolutionary stage and future.
The main-sequence stage: definition of a main-sequence star, mass, luminosity and main-sequence lifetimes, width of the main sequence.
The end of the main-sequence stage and ascent of the giant branch, post-main sequence evolutionary tracks, the triple-alpha reaction, degeneracy and the helium flash, horizontal-branch stars and asymptotic-branch-giant stars (including their internal structures), an evolutionary "rule of thumb": surface density & temperature vary in the opposite sense as core density & temperature.
The main sequence turnoff and star cluster ages, stellar variability, light curves, variability regions in the H-R diagram.
Thermal pulses, planetary nebulae and their nuclear stars, white dwarfs.

The Evolution of High-Mass Stars, Stellar Deaths:
Stellar corpses: white dwarfs, neutron stars (and pulsars), black holes.
Evolutionary changes in high mass stars, multi-shelled energy sources, core collapse and type II supernovae.
Nucleosynthesis: elemental abundances, elemental formation processes.
White Dwarfs: the Chandrasekhar mass limit, type Ia supernovae, novae, physical characteristics: size, mass, density, surface gravity, velocity of escape, superconductivity superfluidity.
Neutron Stars: Formation, structure, pulsars: their discovery, nature, formation, and evolution; the pulsation slowdown rate and the "glitches:" x-ray bursters, pulsating x-ray sources.
Black holes: formation processes, properties, predicted of by general relativity. theory, the Schwarzchild radius, the event horizon, the singularity, the ergosphere. Light cones.
Properties of a black hole: mass, angular momentum and electrical charge. Information sinks.
Falling into a black hole; watching someone fall into a black hole. "Slowing" of time. Space-time interchange.
Observable effects of black holes: gravitational lensing, in mass accretion disks, Cygnus X-1.

\[ R_{Sch} = \frac{2GM}{c^2}, \quad \text{Size of a source of radiation which flickers in time } \Delta t \leq c\Delta t. \]