Example Exam Questions for Module PX 144: "Introduction to Astronomy"

Useful physical constants:

Solar mass:	$M_\odot = 2 \times 10^{30}$ kg
Earth mass:	$M_{\rm Earth} = 6 \times 10^{24}$ kg
Solar luminosity:	$L_\odot = 3.9 \times 10^{26}$ W
speed of light:	$c = 300000\,{\rm km\,s^{-1}}$
Gravitational constant:	$G = 6.67 \times 10^{-11}\,{\rm N\,m^2\,kg^{-2}}$
Hubble parameter:	$H_0 = 70\,{\rm km\,s^{-1}\,Mpc^{-1}}$
Parsec:	$1\,{\rm pc} = 206265\,{\rm AU}$

Question 1 (Solar System):

a) (6 points): Ceres has an orbital period of 4.6 years

i) What is Ceres the semi-major axis in units of AU? {3}
ii) Sketch the location of Ceres orbit in the solar system. {3}

b) (6 points): Geostationary satellites have an orbital period of 24 h such that they are always situated over the same point over the Earth's equator.

i) Why do geostationary orbits have to be circular? {1}
ii) Compute the orbital radius for geostationary satellites. {5}

c) (13 points): i) Several planets in the solar system show volcanic activity or have shown so in the past. Looking at the shield volcanoes on Earth and Mars:
(a) List their major similarities and differences. {4}
(b) What is the reason for the apparent differences? {4}
ii) NASA and ESA are planning to search for extrasolar planets by directly imaging them. Briefly describe the major observational problems that are to be solved before these missions can succeed. {5}

Question 2 (Stars):

a) (18 points): An astronomer observes a star and deduces that it is a main sequence star with a surface temperature of 10000 K.

i) Briefly outline how she might have measured the star's surface temperature. {3}
ii) Sketch a Hertzsprung-Russell Diagram (HRD), showing the location of the star, the Sun, the main sequence, and the supergiants in the diagram. {6}
iii) From the HRD, what spectral type and what approximate mass do you expect the star to have? {3}
iv) Describe how the mass of the star can be measured. {4}
v) Is this mass measurement possible for all stars? {2}

b) (7 points): i) Compute the parallax angle for a star at a distance of 15 pc. {2}
ii) A star has an absolute magnitude of $M = 3$ mag, what is its apparent magnitude at a distance of 15 pc? {3}
iii) What is the luminosity of this star in terms of the solar luminosity, given that the absolute magnitude of the Sun is 5 mag? {2}

Question 3 (Galaxies):

a) (4 points) In 1998, the Sloan Digital Sky Survey discovered a quasar with a redshift of $z = 5$.

i) Using Hubble's law, compute the distance fo this quasar in Mpc and lightyears. Comment on the result. {2}

ii) One of the strongest emission lines of hydrogen is the Lyman α line, which is emitted at $\lambda = 121.567\,\text{nm}$ in the ultraviolet. Given the high redshift of the quasar, would you be able to observe this line in the optical regime (assume the optical waveband is the 300–1000 nm band). {2}

b) (7 points) The astronomical distance ladder is based by determining the absolute magnitude of standard candles using their distances as measured with other distance indicators. Currently, the major distance scale outside of the Milky Way is based on δ Cepheid variables in the Large Magellanic Cloud (LMC), for which two values of the distance modulus are currently being discussed: $m - M = 18.3\,\text{mag}$ and $m - M = 18.7\,\text{mag}$.

A Cepheid is observed in the Virgo cluster with $m = 25.7\,\text{mag}$, its period suggests that $M = -6\,\text{mag}$.

i) What is the distance modulus of the Virgo Cluster? {1}

ii) The Cepheid's absolute magnitude was inferred assuming a LMC modulus of 18.3, what is the relative error of the Virgo distance if the LMC's distance modulus were $m - M = 18.7\,\text{mag}$ instead? {6}

c) (6 points) A black hole with a mass of $10\,M_\odot$ accretes $10^{-7}\,M_\odot$ of material per year.

i) What is the Schwarzschild radius $2GM/c^2$ of the black hole? {1}

ii) Assuming the material falls in from infinity, compute the amount of potential energy released before the accreted material reaches the Schwarzschild radius, and compare this with the luminosity of the Sun.

d) (8 points) The basic assumption of most modern cosmological models is that the universe is isotropic and homogeneous. Discuss what is meant by these two assumptions and describe what types of observations can be used to test whether both assumptions are correct. {8}