ASTR1050
Fall 2025

Equations

$$R_S = \frac{2GM}{c^2}$$

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\Delta t = \gamma \Delta \tau$$

$$L = \frac{L_0}{\gamma}$$

$$d\ (\text{pc}) = \frac{1}{p\ (\text{arcsecs})}$$

$$z = \frac{\lambda_{\text{obs}} - \lambda_{\text{emit}}}{\lambda_{\text{emit}}}$$

$$v = cz$$

$$v = H_0 \cdot d$$

$$t_{\text{universe}} \approx \frac{1}{H_0}$$

$$m_* v_* = m_p \sin(i)\, v_p$$

$$d = \left(\frac{R_p}{R_*}\right)^2$$

$$T_{\text{eq}} = 277 \left(\frac{L_*}{L_\odot}\right)^{0.25} \left(\frac{1\ \text{AU}}{a}\right)^{0.5}\ \text{K}$$

Constants/Conversions

$$1\ L_\odot = 3.828 \times 10^{26}\ \text{W}$$

$$1\ M_\odot = 2 \times 10^{30}\ \text{kg}$$

$$1\ R_\odot = 6.957 \times 10^{8}\ \text{m}$$

$$T_\odot = 5780\ \text{K}$$

$$\sigma_{\text{SB}} = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$$

$$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$$

$$c = 3 \times 10^{8}\ \text{m s}^{-1}$$

$$1\ \text{AU} = 1.5 \times 10^{11}\ \text{m}$$

$$1\ \text{pc} = 3.09 \times 10^{16}\ \text{m}$$

SI prefixes

Name	Symbol	Base 10
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	μ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}
Femto	f	10^{-15}

Figure 1. Messier 101, 'The Pinwheel galaxy,' imaged by Spitzer Space Telescope in 24/8.0/4.5 μm. The red/blue outer spiral arms reveal harsh radiation fields from new, young stars which destroy organic molecules.

Multiple Choice Section (30 %)

1. Globular clusters are:

(a) young groups of massive stars that formed very recently.

(b) dense associations of millions of stars that formed at around the same time as the Milky Way.

(c) large collections of galaxy groups.

(d) dense collections of thousands of galaxies.

2. What distance would you measure to the Sun from Earth on a rocket ship moving 70% the speed of light?

(a) 0.548 AU

(b) 0.714 AU

(c) 1.00 AU

(d) 1.40 AU

3. Why was Harlow Shapley convinced that the Milky Way was all that there is in the Universe and "spiral nebulae" exist within the Milky Way?

(a) Spiral nebulae were notably absent in the Zone of Avoidance.

(b) Spiral nebulae were shown to be gravitationally bound to the Milky Way.

(c) The large size of our galaxy implies an unimaginable distance to Andromeda.

(d) Individual novae were detected in Andromeda.

4. Star formation occurs in spiral galaxies mostly in the:

(a) spiral arms.

(b) halo.

(c) bulge.

5. Which are indications of dark matter? Select all that apply.

(a) Motions in the Bullet Cluster.

(b) Spiral arms as the result of standing density waves.

(c) Gravitational lensing in merging galactic groups clusters.

(d) Flat galactic rotation curves.

6. What must you measure to determine the distance to a Cepheid variable star?

(a) Its temperature.
(b) Its color.
(c) Its spectral type.
(d) The period of its pulsations.

7. Which astronomical phenomenon do we use to measure large extragalactic distances?

(a) Parallax.
(b) Cepheid variable stars.
(c) Type Ia supernovae.
(d) Globular clusters as standard candles.

8. What is dark energy?

(a) The force that accelerates the expansion of the Universe.
(b) A form of matter that does not interact with light.
(c) A component of the Universe composed of baryons.
(d) A component of the Universe composed of photons.

9. Cosmological redshift describes:

(a) Photons losing energy when moving in curved spacetime.
(b) Photon wavelengths shifting due to radial velocity.
(c) Photon wavelengths stretching due to the expansion of the Universe.
(d) Length contraction when moving close to the speed of light.

10. Which of the methods listed is most commonly used to study exoplanets?

(a) Radial velocity.
(b) Mico-lensing.
(c) Imaging.
(d) Pulsar timing delays.

Short answer (20 %)

11. The following items are some key evidences for profound discoveries in astronomy in the 20th century. Sort the terms into the appropriate fields.

Word bank:

(A) Cosmic Microwave Background, (B) expansion of the Universe, (C) gravitational lensing, (D) gravitational redshift, (E) large-scale structure, (F) length contraction, (G) Michelson-Morely experiment, (H) nucleosynthesis, (I) time dilation, (J) precession of Mercury's perihelion

a. General Relativity:_____

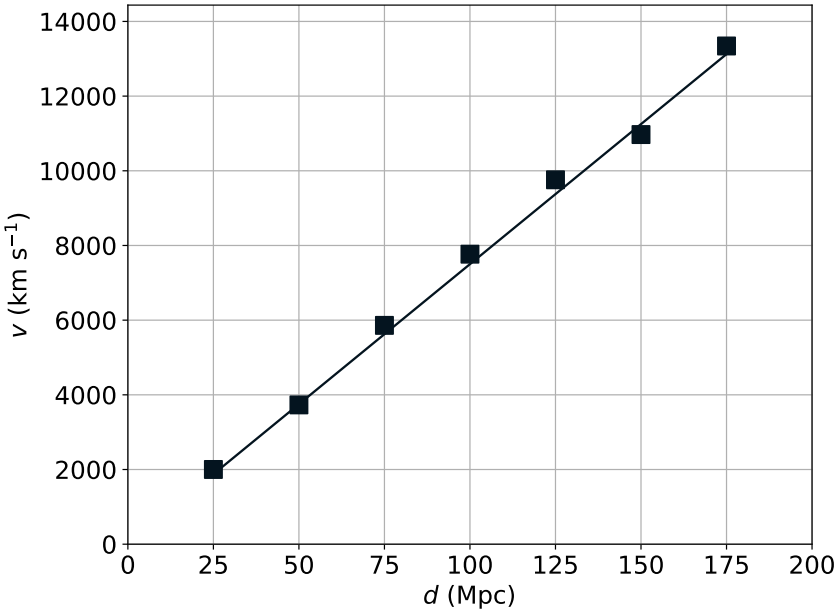
b. Special Relativity:_____

c. Big Bang:_____

Open ended (50 %)

12. Use the plots provided to answer the following questions.

(a) **Observing distant galaixes, you produce the following Huble diagram. What is the expansion rate of the universe in units km s^{-1} Mpc^{-1}?**

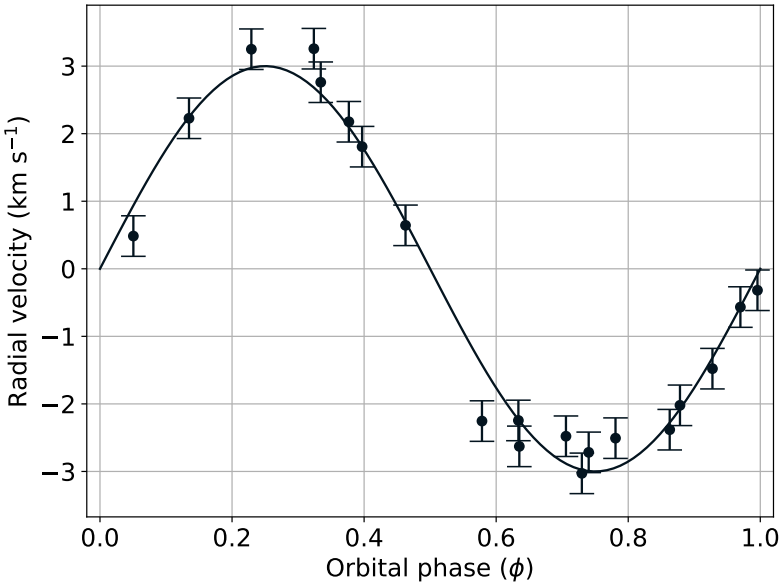


(b) **A hypothetical universe has H_0 of 100 km s^{-1} Mpc^{-1}. What is the redshift of a galaxy 116 Mpc away?**

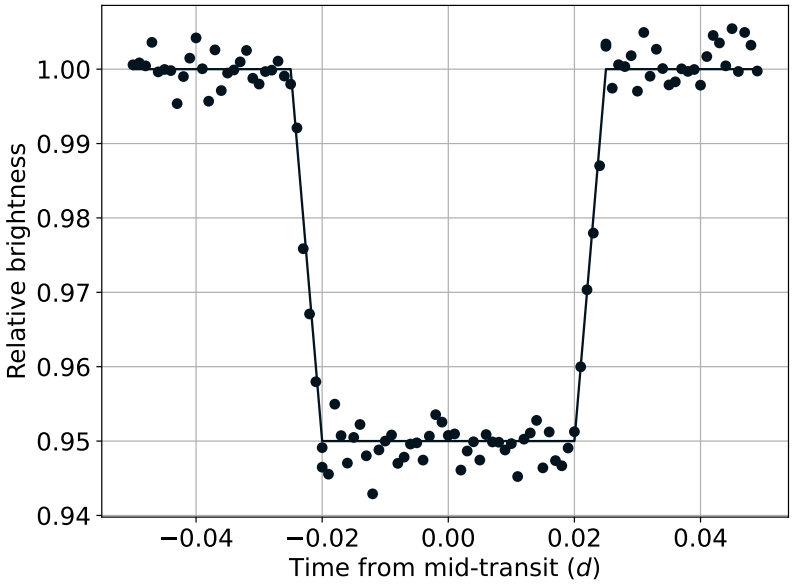
(c) **The Ca K line (rest wavelength 3933 Å) in a distant galaxy is observed at 4044 Å. How far away is it, in Mpc? Assume H_0 of 70 km s^{-1} Mpc^{-1}.**

Continued on next page.

(d) **Suppose you are observing a star and exoplanet using the radial velocity method, and you produce the following radial velocity diagram. If the host star is identical to the Sun and the planet is moving at 300 km s^{-1}, what is the projected mass of the planet, in solar masses?**



(e) **Suppose you are observing a star and exoplanet using the transit method, and produce the following light curve. If the host star is has a radius of 10 R_{Jup}, what is the exoplanet's radius?**



Answer key

1. **B**
2. **B**
3. **C**
4. **A**
5. **A, C, D**
6. **D**
7. **C**
8. **A**
9. **C**
10. **A**
11. **a. C, D, J**
    b. F, G, I
    c. A, B, E, H
12. **a.** 75 km s^{-1} Mpc^{-1}
    b. 0.0387
    c. 121 Mpc
    d. $\frac{1}{100}$ $M_\odot$
    e. 2.24 R_{Jup}