PEP 151 Introduction to Astronomy, Spring 2022
Quiz 1, March 4th 2022

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"I pledge my honor that I have abided by the Stevens Honor System."

Name (sign): Alex Gaskins

Problems 1-20: multiple choices. Enter your choices below.
Problems 21-22: provide the answers using the space below each problem.

Enter your answers to problems 1 to 20 here:

Problem 1: A
Problem 2: B
Problem 3: E
Problem 4: B (A X)
Problem 5: D (E X)
Problem 6: B, ~~D~~ (B X)
Problem 7: B
Problem 8: B
Problem 9: B
Problem 10: D

Problem 11: A
Problem 12: A
Problem 13: C
Problem 14: E
Problem 15: B
Problem 16: A
Problem 17: C
Problem 18: A
Problem 19: A (B X)
Problem 20: E

For grader's use only
Problem 21 score 3 / 3
Problem 22 score 3 / 3

Total score 22 / 26

Problem 1:

Our Sun is just one of the billions of stars in our Milky Way Galaxy. Our Milky Way Galaxy and Andromeda are the two biggest galaxies in the local group. If a photon is emitted from the star closest to our solar system, and at the same time another photon is emitted from Andromeda, assuming both photons are travelling towards us and nothing intercepts them, which photon will reach us first?

(A) The one from the nearest star
(B) The one from Andromeda
(C) Both will get here at the same time

Problem 2:

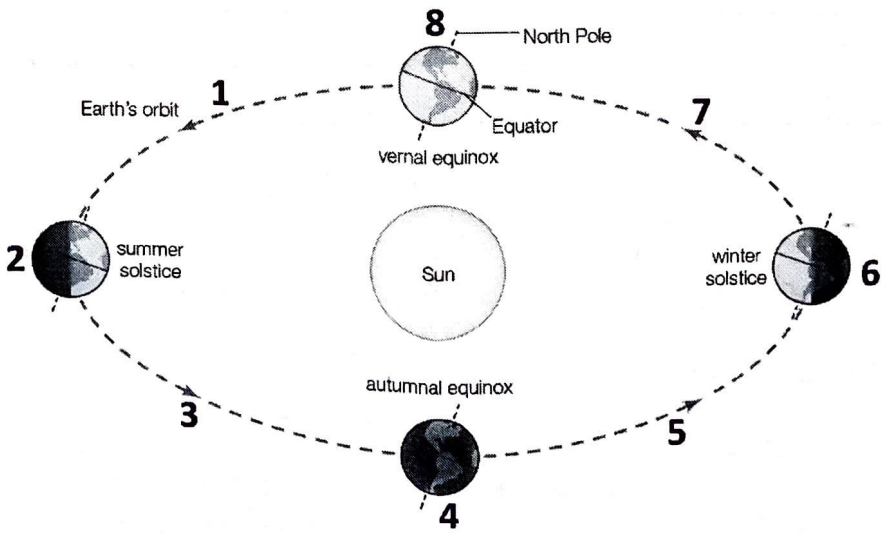
We know that a white dwarf of 1 solar mass is about as large as our Earth, and more massive white dwarfs are even smaller. This means Earth is _____ than white dwarfs.

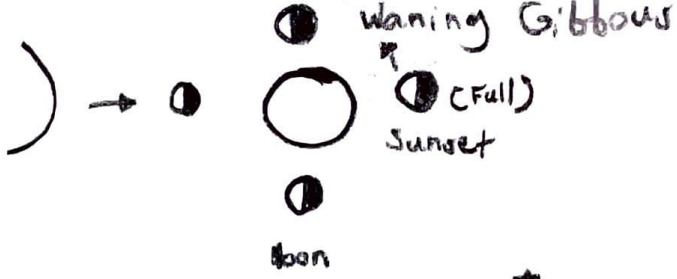
(A) denser than (B) less dense than (C) equally dense as

Problem 3:

In the diagram below, various positions along Earth's orbit are labelled. The **fall in the northern hemisphere** is between which positions?

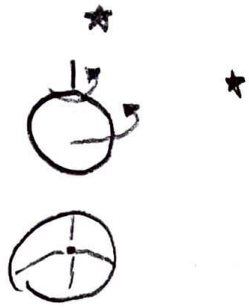
(A) Between positions 1 and 3 (B) Between positions 2 and 4 (C) Between positions 6 and 8
(D) Between positions 7 and 1 (E) Between positions 4 and 6 (F) Between positions 8 and 2





Problem 4:

The moon is setting in the western sky one hour after the sunset. The phase of the moon is:



(A) waxing crescent
(B) waning gibbous
(C) first quarter
(D) waxing gibbous
(E) waning crescent
(F) third quarter

Problem 5:

Which of the following statements is true?

(A) If the tilt of Earth's axis changes from 23.5° to 0°, we'd have more extreme seasons on Earth.
(B) If the shape of the current lunar orbit gets more elongated, lunar eclipses would happen twice as often.
(C) The reason that lunar eclipses do not happen every single month is that the lunar orbital plane coincides with the plane in which Earth orbits the Sun.
(D) Tidal locking between Earth and the moon is the reason solar eclipses happen.
(E) None of the above statements is true.

LE occur moon enters Earth shadow

Problem 6:

Which of the following is true about the patterns in the sky viewed from Earth?

(A) Polaris is famous because it is the brightest star in the sky.
(B) Polaris is the north star right now because it is near the north celestial pole, but due to the precession of Earth's axis, it will not always be around the north celestial pole.
(C) If you are at the north pole, you would see stars rising from the east and setting to the west.
(D) If you are at 50 degrees N, you would see the north star 40 degrees above your local horizon.

Problem 7:

It does not matter where you are on Earth (e.g. north pole, equator, south pole), when you look towards the zenith in your local sky, you always see the same set of stars at night. True or false?

(A) True (B) False

Problem 8:

Stars in the same constellation (regions in the sky) are all at the same distance to us because they are all on the surface of the celestial sphere. True or false?

(A) True (B) False

Problem 9:

The reason that it is hot in the summer and cold in the winter is because Earth is much closer to the Sun in the summer. True or false?

(A) True (B) False

Problem 10:

Which of following statements about the events in the history of astronomy is NOT true?

(A) Tycho's observation of the first supernova is one of the pieces of evidence against the old belief that sky is perfect, permanent, and never changes.
(B) Galileo's observation of Jupiter's moons showed that not everything in the sky orbited Earth.
(C) The reason Tycho did not detect stellar parallax is because stars are too far away for the parallax to be seen with naked eye observations.
(D) We sometimes see apparent retrograde motion of Mars, and that's because Mars sometimes reverses its orbital direction around the Sun due to its gravitational interactions with Earth.

Problem 11:

One of the pieces of evidence supporting the Sun-centered model instead of Earth-centered model is the observed phases of Venus. True or false?

(A) True (B) False

Problem 12:

If satellite A is orbiting Earth in a circular orbit at a height h above earth surface, while satellite B is orbiting Earth in a circular orbit at a height 2h above earth surface, which one is orbiting at a higher (linear) speed?

(A) Satellite A (B) Satellite B

orbital speed = $\sqrt{\frac{GM}{r}}$

so smaller r = larger velocity

Problem 13:

A planet is orbiting a star of 1 solar mass with an average orbital distance of 4.5e8 km. What is its orbital period? (1 AU = 1.5e8 km)

↳ 3 AU

(A) 2.8 years (B) 2.8 months (C) 5.2 years (D) 8 years (E) 8 months

$p^2 = a^3$

? $p = \sqrt{a^3} = \sqrt{3^3} = 5.2$ years

Problem 14:

When a gas cloud collapses, the rate of rotation increases as the size decreases. Which law of physics is most suitable for the description of this phenomenon?

(A) Conservation of energy. (B) Doppler effect. (C) Conservation of linear momentum.
(D) Newton's third law. (E) Conservation of angular momentum.

Problem 15:

Which of the following statement about telescopes and observation is NOT correct?

(A) Refractor telescopes use primarily lenses while reflector telescopes primarily use mirrors.
(B) If you want to observe a planet, it is better to observe it in the X-ray wavelength range than the infrared wavelength because planets glow brighter in X-ray than in infrared.
(C) We put certain telescopes in space to get around the strong absorption of light at certain wavelengths due to Earth's atmosphere, as well as to avoid "blurring" and light pollution.
(D) The diffraction limited angular resolution of a telescope depends on its light collecting area and the wavelength of the observation.

Problem 16:

You did spectroscopic observations on two objects and noticed that the absorption line that was supposed to occur at 510 nm in the rest lab frame occurred at 520 nm for object A and at 500 nm for object B. What can you conclude about the two objects' radial motion from us?

(A) Object A is moving away from us, and object B is moving towards us, at the same speed.
(B) Object A is moving towards us, and object B is away from us, at the same speed.
(C) Object A is moving away from us faster than object B is moving towards us.
(D) Object A is moving towards us faster than object B is moving away from us.

Problem 17:

Two stars, the temperature of star A is 5000 K and star B has a temperature of 15000 K. If they have the same surface area, which of the following is true about their total power output?

(A) $16P_A = P_B$ (B) $P_A = 16P_B$ (C) $81P_A = P_B$ (D) $P_A = 81P_B$
(E) $2P_A = P_B$ (F) $P_A = 2P_B$

$$P = \sigma T^4$$

$$\sigma T_A^4 = \sigma T_B^4$$

$$P_A \times 81 = P_B$$

$$(5000)^4 = (15000)^4$$

$$\frac{(15000)^4}{(5000)^4} = 81$$

Problem 18:

The wavelength at which the blackbody radiation is the most intense is shorter for a high temperature object than a low temperature object. True or false?

(A) True (B) False

$$\lambda_{max} = \frac{2,900,000}{T}$$

Problem 19:

Which statement is true about the ***dark lines*** shown in the spectrum below?

(A) They are emission lines.
(B) They can be produced when light from a dense hot source passes through a cooler cloud of gas.
(C) They are produced when an electron in an atom makes a downward transition jumping from a higher energy level to a lower energy level.
(D) They are produced when a gas cloud is completely ionized (all electrons have escaped the atoms).

Problem 20:

Assuming perfect optics, you are able to resolve fine features as small as 0.04 arcsec in the narrow wavelength range centered around 660 nm with a 4-meter telescope. If you want to make another observation with the same telescope, but at a different wavelength of 1980 nm, what's the size of the finest feature you can resolve then?

(A) 0.01 arcsec (B) 0.02 arcsec (C) 0.04 arcsec (D) 0.08 arcsec
(E) 0.12 arcsec (F) None of the above

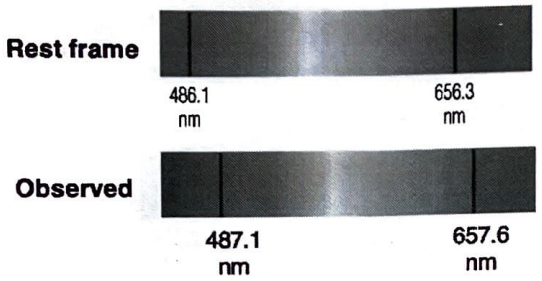
$\lambda = 1980_{nm}$ $D = 4$ m.

$$2.5 \cdot 5 \frac{\lambda}{D} = 0.12375 \text{ arcsec}$$

You need to show steps for the following two problems.

Problem 21 (3 points).

Give the following 2 absorption spectra, what is the radial speed of this object relative to the speed of light? Is it moving away or moving towards us?



$$V_{rad} = \left[\frac{487.1 - 486.1}{486.1}\right] c$$

$\approx 0.2\% = 0.0057\ c$

$617,156.96$ m/s

$$\frac{V_{rad}}{c} = \frac{\lambda_{shift} - \lambda_{rest}}{\lambda_{rest}}$$

$$V_{rad} = \left[\frac{\lambda_{shift} - \lambda_{rest}}{\lambda_{rest}}\right] c$$

$$V_{rad} = \left[\frac{657.6 - 656.3}{656.3}\right] c$$

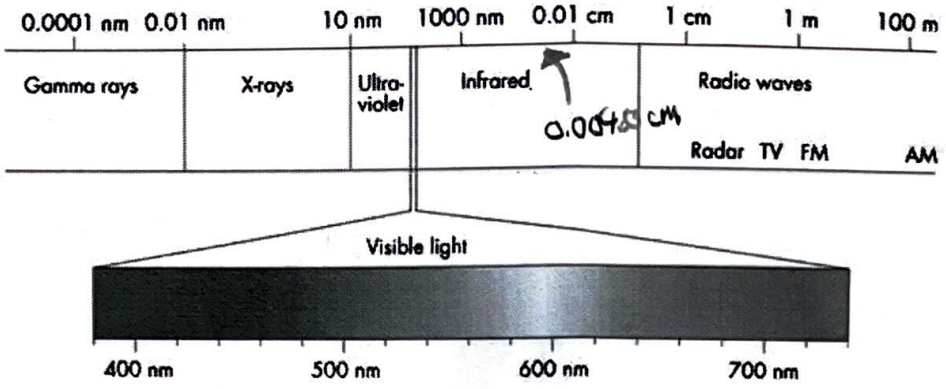
$$V_{rad} = [0.001981]\ c = 594,240.44 \text{ m/s}$$

0.2 % of the speed of light

We can conclude that the object is moving away from us

Problem 22 (3 points).

The temperature at the top of the cloud on Neptune is about 60 K. Which wavelength (in ***cm***) does Neptune's emission peak at? Which part of the electromagnetic spectrum does it fall on?



$$T = 60\,K$$

$$\lambda_{max} = \frac{2,900,000}{T} = \frac{2,900,000}{60} \checkmark$$

$$\lambda_{max} = 48,333.33\ nm$$

$$\left(48,333.33 \times 10^{-9}\right) m$$

$$\frac{100\ cm}{1\ m}\left[48,333.33 \times 10^{-9}\ m\right]$$

$\lambda = 0.00483$ cm. ✓

Thus, it falls under infrared. ✓

Equations that might be useful:

Density = Mass / Volume

Blackbody radiation: $P = \sigma T^4$

$$\lambda_{\substack{\max \\ \text{intensity}}} \approx \frac{2,900,000}{T \text{ (in Kelvin)}} \text{ nm}$$

Kepler's 3rd law: $P^2 = a^3$

Newton's version of Kepler's 3rd law:

$$p^2 = \frac{4\pi^2}{G(M_1+M_2)} a^3$$

$(G = 6.67 \times 10^{-11} \frac{\text{m}^3}{\text{kg} \times \text{s}^2}$ is the gravitational constant.)

Orbital speed of circular orbits:

$$v = \sqrt{\frac{GM}{r}}$$

Redshift/Blueshift, (low) radial speed:

$$\frac{\mathbf{v}_{\text{rad}}}{c} = \frac{\lambda_{\text{shift}} - \lambda_{\text{rest}}}{\lambda_{\text{rest}}}$$

Diffraction limited angular resolution:

In radian:

$$\theta_{\min} = 1.22 \frac{\lambda}{D}$$

In arcsecond:

$$\theta_{\min} = \mathbf{2.5e5} \frac{\lambda}{D}$$