**Astronomy C10 / L&S C70U – Fall 2016 – Professor Alex Filippenko**

**Midterm Exam #1 — 7 October 2016**

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**Print** name: Solutions (A) **Sign** name: _____ Student ID #: _____

**Print** your GSI's Name: _____ Discussion section # (or day, time): _____

**Print and sign your name on your SCAN-TRON 882 form.** Under "subject," please put your GSI's name and your discussion section number.

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CLOSED BOOK, CLOSED NOTES, NO CALCULATORS

**Mark all answers on SCAN-TRON form 882. Use a #2 pencil.** Completely fill in the appropriate bubble. *Be sure to thoroughly erase all altered answers and stray marks!*

For true/false questions: mark bubble **A** if the statement is *true*, and bubble **B** if *false*. For multiple choice questions: mark the bubble corresponding to the *single best answer*.

All 25 questions carry equal weight. Read each question *carefully* before answering. **There is no penalty for guessing.** If you need extra room for work, use the last (blank) page.

**Turn in *both* this multi-page set of questions *and* your SCAN-TRON form.**

**DO NOT OPEN THIS EXAM UNTIL TOLD TO DO SO!!**

*Time limit:* 45 minutes — **budget your time appropriately. GOOD LUCK!**

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**Possibly Useful Information**

$d$ (pc) $= 1/p$ (arcsec) $\quad d = vt \quad$ density $\rho = M/V \quad c = 3 \times 10^5$ km/s

For a sphere, $V = \frac{4}{3}\pi R^3$, $A_{\rm surface} = 4\pi R^2 \quad$ For a circle, $A = \pi R^2$, $C = 2\pi R \quad \pi \approx 3.14$

There are about $3.2 \times 10^7$ seconds per year, and 86,400 (roughly $10^5$) seconds per day

Degrees Kelvin = degrees Centigrade + 273; Fahrenheit = (9/5)Cent. + 32 $\quad \theta \approx \lambda/D$

1 AU $= 1.5{\times}10^8$ km $\approx 8.3$ light minutes $\quad$ 1 light year (ly) $\approx 63,000$ AU $\approx 9.5{\times}10^{12}$ km $\approx 10^{13}$ km

1 pc $= 3.26$ ly $\approx 3 \times 10^{18}$ cm $\approx 3 \times 10^{13}$ km $\quad$ 1 Å $= 10^{-8}$ cm $= 10^{-10}$ m $= 0.1$ nm

$60''$ (arcsec) $= 1'$ (arcmin), $60' = 1°$ (degree), $360°$ = full circle $= 2\pi$ radians = 24 hours

$\lambda_{\rm peak} T \approx 3 \times 10^6$ nm K $= 3 \times 10^7$ Å K $\quad \lambda f = c \quad P = 1/f \quad \mathcal{E} = \sigma T^4 \quad E = hf$

$z = (\lambda - \lambda_0)/\lambda_0 = \Delta\lambda/\lambda_0 \approx v/c$ if $v \lesssim 0.2c \quad z = \sqrt{\frac{1+(v/c)}{1-(v/c)}} - 1$ for all $v \leq c$.

$F = GM_1M_2/d^2 \quad M_1 r_1 = M_2 r_2 \quad L \propto M^4 \quad R \propto M^{0.75} \quad p + e^- \rightarrow n + \nu$

$R_{\rm S} = 2GM/c^2 \quad R_{\rm photon\ sphere} = 3GM/c^2 \quad M_{\rm Ch} = 1.4\ M_\odot \quad F = ma$

$L_{\rm thermal} = 4\pi R^2 \sigma T^4$ (for a sphere) $\quad b = L/(4\pi d^2) \quad E = mc^2 = m_0c^2[1 - (v^2/c^2)]^{-1/2}$

$v = H_0 d$, where $H_0 \approx 70$ km/s/Mpc $\quad \Omega = \rho/\rho_{\rm crit} \quad \rho_{\rm crit} = 3H_0^2/(8\pi G) \quad M = v^2R/G$

$N = R_* f_s f_p n_e f_l f_i f_c L$, where $R_* \approx N_*/T$ ($N_*$ = # stars in galaxy, $T$ = age of galaxy)

$P^2 = kR^3$ [$k \approx$ constant $\approx 4\pi^2/(GM_1)$ if $M_1 >> M_2$]; in general, $P^2 = (4\pi^2R^3)/[G(M_1 + M_2)]$

For planets, $v \propto 1/\sqrt{R} \quad t_{\rm moving} = (t_{\rm rest})[1 - (v^2/c^2)]^{1/2} \quad L_{\rm moving} = (L_{\rm rest})[1 - (v^2/c^2)]^{1/2}$

**Be sure you answer question #1 correctly (6 points off if incorrect)!**

(1) The instructor of Astronomy C10 / L&S C70U, Fall 2016 (i.e., this class) is
(a) Alex Filippenko.
(b) Hillary Clinton.
(c) Donald Trump.
(d) Vladimir Putin.
(e) Madame Curie.

(2) (T)or F. We can determine the chemical composition of gases near the surfaces of stars by measuring the absorption lines in spectra of these stars.

(3) The amount of time it takes light to travel from the Sun to Earth is most nearly
(a) 0 seconds (i.e., instantaneously).
(b) 10 milliseconds.
(c) 10 seconds.
(d) 10 minutes.
(e) 10 hours.

(8.3 minutes)

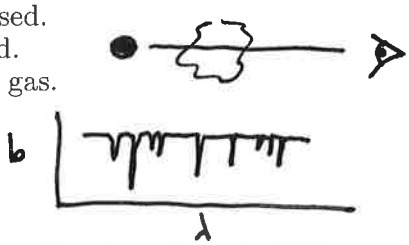
(4) If we double the *diameter* of a telescope's primary mirror or lens, the light-gathering power increases by a factor of
(a) 1 (i.e., doesn't increase).
(b) 2.
(c) 4.
(d) 8.
(e) 16.

$\frac{A_2}{A_1} = \left(\frac{D_2}{D_1}\right)^2 = 2^2 = 4$ (CS-47)

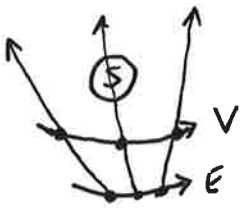
(5) Which one of the following statements is TRUE?
(a) If you see a star passing overhead around midnight on August 7, then on October 7 that same star will pass overhead around 4 am.
(b) In general, the stars within a given constellation are all at approximately the same distance from Earth.
(c) Earth's northern hemisphere is hotter in the summer than in the winter mostly because Earth's tilt brings the northern hemisphere closer to the Sun in the summer.
(d) Over the course of a year, a person in Berkeley can see the entire celestial sphere at night.
(e) Some parts of the celestial sphere that are visible from Berkeley at night in December are also visible from the South Pole at night in June.

South pole: see all of southern celestial hemisphere (SCH).
Berkeley: see some of CSH. So there is overlap.


(6) Imagine we are viewing a hot star through a cloud of cold gas. Which one of the following best describes what we would see in its spectrum?
(a) A continuum, with absorption lines from the gas superimposed.
(b) A continuum, with emission lines from the gas superimposed.
(c) A continuum, with no emission or absorption lines from the gas.
(d) Nothing, because the gas absorbs everything.
(e) Only emission lines from the gas.




(7) (T)or F. Venus undergoes retrograde motion when it is on the same side of the Sun as Earth is, rather than when it is on the opposide side of the Sun.




See Homework 4, Q3.
Venus "passes up" Earth → retrograde motion.

(8) Which one of the following statements is NOT a consequence of Newton's laws?

(a) The gravitational force that Earth exerts on you is equal in strength to the gravitational force that you exert on Earth.

(b) A force is required to change the direction of an object moving with constant speed.

(c) The Moon is continually falling toward Earth, but it never hits Earth because of its tangential motion.

(d) If two satellites are orbiting Earth at the same distance, the satellite with greater mass will feel a greater acceleration than the one with less mass.

(e) Kepler's "constant" is actually not a constant; it is a bit smaller for Jupiter's orbit around the Sun than Earth's orbit around the Sun.

$\frac{GMm}{d^2} = ma \rightarrow a = \frac{GM}{d^2}$, independent of $m$ (CS-89)

(9) Imagine a star with a single exoplanet orbiting it. If the exoplanet's mass were doubled, the observed Doppler-shift variations of the star would be _____. If the semimajor axis of the exoplanet's orbit were doubled, the observed Doppler-shift variations of the star would have _____.

(a) larger; a shorter period
(b) smaller; a longer period
(c) larger; a longer period
(d) the same; the same period
(e) smaller; a shorter period

Mass doubled → more gravity
Distance doubled → longer period

(10) T or F Water faucets and showers in bathrooms typically have blue indicating cold and red indicating hot because cold objects tend to thermally emit light having shorter wavelengths than hot objects, as in the example of cold blue glaciers and hot orange coals.

(11) Earth is at a distance of 1 AU from the Sun and has an orbital period of 1 year. Suppose hypothetical planet Goni orbits the Sun with an orbital period of 8 years. What is Planet Goni's average distance from the Sun?

(a) 4 AU
(b) 2 AU
(c) 64 AU
(d) 8 AU
(e) $8^{(3/2)}$ AU

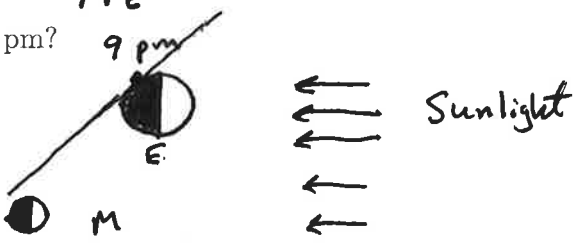
$P^2 \propto R^3$

$\left(\frac{P_G}{P_E}\right)^2 = \left(\frac{R_G}{R_E}\right)^3$ $\quad 8^2 = \left(\frac{R_G}{R_E}\right)^3 = 64$

$R_G/R_E = 4 \quad R_G = 4\,AU$

(12) Which phase of the Moon rises at approximately 9 pm?

(a) Waxing crescent
(b) Waxing gibbous
(c) Waning crescent
(d) Waning gibbous
(e) Full

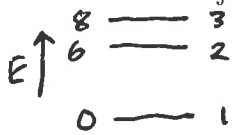



(13) T or F Rounding to the nearest 5%, the species *Homo sapiens* (i.e., humans) first appeared when Earth was about 90% of its current age.

About 100% (CS-8)

(14) Suppose hypothetical atom Rachel has only three bound electron energy levels labeled 1, 2, and 3, with respective energy levels $E_1 = 0$ units, $E_2 = 6$ units, and $E_3 = 8$ units. If the wavelength of a photon emitted when an electron jumps from level 3 to level 2 is 600 nm, then the wavelength of a photon emitted when an electron jumps from level 2 to level 1 is

(a) 100 nm.
(b) 200 nm.
(c) 300 nm.
(d) 1200 nm.
(e) 1800 nm.




$E_{3\to2}$ = 2 units (8 - 6)

$E_{2\to1}$ = 6 units (6 - 0)

So $E_{2\to1}$ is 3 times the energy of $E_{3\to2}$.

(600/3 = 200 nm) $E = hf = \frac{hc}{\lambda}$, so $\frac{1}{3}$ the wavelength.

(15) Venus is the hottest planet in our Solar System because of its thick atmosphere. This is because

(a) Venus' thick atmosphere is opaque to both visible and infrared light.
(b) Venus' thick atmosphere traps X-rays and ultraviolet light from the Sun, thus making the planet extra hot.
(c) Venus' thick atmosphere is transparent to both visible and infrared light.
(d) Venus' thick atmosphere is opaque to visible light and transparent to infrared light.
(e) Venus' thick atmosphere is transparent to visible light and opaque to infrared light.

(16) The daytime sky is blue primarily because

(a) blue sunlight is preferentially scattered by air molecules.
(b) red sunlight is preferentially scattered by air molecules.
(c) the oceans preferentially reflect blue light into the sky.
(d) air molecules preferentially radiate at blue wavelengths.
(e) blue light travels through the atmosphere more easily than red light.

(17) T or F. If Star Elan is moving away from Earth with a speed of 100 km/s, and you are in a rocket ship going toward Star Elan with a speed of 200 km/s relative to Earth, Star Elan's light will appear blueshifted to you.

Rocket ship approaches Elan, 100 km/s. Blueshift.

(18) Which one of the following best describes the reason Pluto was demoted from being a genuine planet and promoted to the status of "dwarf planet"?

(a) It orbits its center of mass with its main moon, Charon.
(b) It is too small and is thus not quite spherical.
(c) Its orbit sometimes brings it closer to the Sun than Neptune.
(d) Its orbit is far more inclined than those of the other planets.
(e) It has not cleared most other objects from its neighborhood.

(19) T or F. The asteroid belt is inside the Sun's Roche limit and thus could not overcome the Sun's tidal forces to form a planet. The terrestrial planets did not suffer this fate because they are held together by electromagnetic forces, which are much stronger than gravity.

(20) Which one of the following statements about eclipses is FALSE?

(a) The phase of the Moon must be "new" in order to see a total solar eclipse from Earth.
(b) The minimum amount of time between a lunar eclipse and a solar eclipse is about 2 weeks.
(c) A given total solar eclipse can be seen from more than half of the area of Earth's surface.
(d) A given total lunar eclipse can be seen from more than half of the area of Earth's surface.
(e) During a total lunar eclipse as seen from Earth, an observer on the Moon would see a total solar eclipse, but with a ring of orange/red light surrounding Earth's silhoutte.

(21) Which of the following characteristics describe terrestrial planets relative to jovian planets in the Solar System? Terrestrial planets (I) are smaller, (II) have shorter day/night cycles, (III) are more dense.

(a) I only
(b) I and II
(c) I and III
(d) II and III
(e) I, II, and III

(22) T or (F) Chromatic aberration in the lenses in our eyes causes stars to "twinkle."

(23) Consider two stars emitting like blackbodies. Suppose Star Ben is twice as hot as Star Geri. Which one of the following statements is NOT NECESSARILY TRUE?

(a) Star Ben's spectrum peaks at a wavelength half that of Star Geri's spectrum.
(b) Star Ben is more luminous than Star Geri.
(c) The two stars have the same value for the product of their surface temperature and the wavelength at which their spectrum peaks.
(d) Star Ben emits more total energy per unit surface area per second than Star Geri.
(e) Star Ben emits more energy per unit surface area per second than Star Geri at all wavelengths.

Ben emits 16 times as much energy per second per unit area ($\mathcal{E} = \sigma T^4$). But Ben might be much smaller than Geri ($< \frac{1}{4}$ size)(radius). So less luminous.

(24) Which choice below gives the correct ranking, from greatest to smallest, of the gravitational force exerted by the Moon on Earth? (Note that "near side" means the side of Earth closest to the Moon, "center" means the center of Earth, and "far side" means the side of Earth farthest from the Moon.)

(a) The force is the same everywhere.
(b) Near side, center, far side.
(c) Far side, center, near side.
(d) Center is greatest; near side and far side are the same but less.
(e) Impossible to say without more information.


$$F = \frac{GMm}{d^2}$$

(25) Which one of the following statements about comets is TRUE?

(a) Most comets have highly eccentric orbits with a period of $< 200$ years.
(b) Comet impacts are not considered as destructive as asteroid impacts because of a comet's relatively low density compared with that of an asteroid.
(c) Many comets are located in the asteroid belt.
(d) The tail of a comet glows because it is chemically burning.
(e) The time interval when a comet's tail is long is much less than the time interval when a comet's tail is short.

**End of Examination**

(A comet spends very little time near the Sun.)