Name:______________________________

Intro Astro Lab Prep Quiz: Lab 12: Cosmos

Instructions: There are X multiple-choice problems each worth 1 mark for a total of X marks altogether. Choose the **BEST** answer, completion, etc. Leave no answers blank. If you do not know answer, eliminate wrong ones and guess. Read all responses carefully. **NOTE** long detailed responses won't depend on hidden keywords: keywords in such responses are bold-faced capitalized.
This is a $2X$ minute quiz.

Answer Table for the Multiple-Choice Questions

	a	b	c	d	e		a	b	c	d	e
1.	O	O	O	O	O	11.	O	O	O	O	O
2.	O	O	O	O	O	12.	O	O	O	O	O
3.	O	O	O	O	O	13.	O	O	O	O	O
4.	O	O	O	O	O	14.	O	O	O	O	O
5.	O	O	O	O	O	15.	O	O	O	O	O
6.	O	O	O	O	O	16.	O	O	O	O	O
7.	O	O	O	O	O	17.	O	O	O	O	O
8.	O	O	O	O	O	18.	O	O	O	O	O
9.	O	O	O	O	O	19.	O	O	O	O	O
10.	O	O	O	O	O	20.	O	O	O	O	O

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012 qmult 00110 1 4 3 easy deducto-memory: Edwin Hubble discovers galaxies

1. "Let's play *Jeopardy*! For $100, the answer is: This astronomer discovered the extragalactic nature of the spiral nebulae (now called spiral galaxies)."

   Who is ____________, Alex?

   a) Vesto Slipher (1875–1969) b) Albert Einstein (1879–1955)
   c) Edwin Hubble (1889–1953) d) Georges Lemaitre (1894–1966)
   e) E.A. Milne (1896–1950)

   SUGGESTED ANSWER: (c)

   Wrong answers:
   a) As Lurch would say AAAARGH.

   Redaction: Jeffery, 2013jan01

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012 qmult 00120 1 4 2 easy deducto-memory: spiral nebulae

2. Observed galaxies were originally not known to be galaxies though speculation that they were goes back to the 17th century. The spiral nature of some of the observed galaxies was known from mid-19th century on. These galaxies with a spiral nature were usually called ____________________ from the mid-19th century to circa 1924 and even in later years by some including Edwin Hubble (1889–1953) who had proven they were galaxies.

   a) island universes b) spiral nebulae c) other Milky Ways d) star clusters
   e) star whirlpools

   SUGGESTED ANSWER: (b)

   Wrong answers:
   a) The term island universes was used by some, but at least in the time frame mentioned spiral nebulae became most used or so your truly thinks (see Wikipedia: Andromeda Galaxy: Observation history).

Redaction: Jeffery, 2013jan01

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012 qmult 00130 1 4 4 easy deducto-memory: redshift and Doppler shift formulae

3. The cosmological redshift and Doppler shift are both shifts in wavelength of spectrum of electromagnetic radiation between emission and absorption. They are related, but different, effects. The cosmological redshift is caused by the ________________ and the Doppler shift by ordinary velocities relative to inertial frames. but

   a) space b) degrowth of space c) quarks d) growth of space e) general relativity

   SUGGESTED ANSWER: (d)

   Wrong answers:
   e) Not the best answer.

   Redaction: Jeffery, 2013jan01

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012 qmult 00140 1 4 1 easy deducto-memory: redshift and Doppler shift calculation 1

4. The 1st order cosmological redshift and 1st order Doppler shift have the same formula in appearance $v = (\Delta\lambda/\lambda)/c$, where $z = \Delta\lambda/\lambda$ is relative wavelength shift, v is the recession velocity for the cosmological redshift and ordinary velocity relative to an inertial frame for the Doppler shift, and c is the vacuum speed of light. Given $v = 1000\,\mathrm{km/s}$ and $2.99792458\times10^5\,\mathrm{km/s}$, what is $z = vc$ to 3-digit accuracy.

   a) $z = 0.00334$. b) $z = 0.333$. c) $z = 0.533$. d) $z = 0.00534$. e) $z = 1.00$.

   SUGGESTED ANSWER: (a)

   Wrong answers:
   e) Bad guess.

   Fortran-95 Code

```
        print*
        ckms=2.99792458e5_np ! % http://en.wikipedia.org/wiki/Speed_of_light
        v1=1000.0_np
        v2=2000.0_np
        z1=v1/ckms
        z2=v2/ckms
        print*,'z1,z2'
        print*,z1,z2
! 3.33564095198152049574E-0003  6.67128190396304099149E-0003
```

   Redaction: Jeffery, 2013jan01

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012 qmult 00150 1 4 2 easy deducto-memory: redshift and Doppler shift formulae 1st order

5. The 1st order cosmological redshift and 1st order Doppler shift have the same formula in appearance ________________, but the interpretation is of v is different. For the cosmological redshift, v is recession velocity which is a rate of growth of space literally according to general relativity. For the Doppler shift, v is ordinary velocity measured relative to an inertial frame.

   a) $z = vc$ b) $z = v/c$ c) $z = (v/c)^2$ d) $z = (vc)^2$ e) $z = 1/(vc)^2$

   SUGGESTED ANSWER: (b)

   Wrong answers:
   a) Nah.

   Redaction: Jeffery, 2013jan01

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012 qmult 00210 1 4 2 easy deducto-memory: fiducial value of Hubble constant

6. A fiducial value (i.e., reference value) for the Hubble constant is:

   a) 50 (km/s)/Mpc. b) 70 (km/s)/Mpc. c) 85 (km/s)/Mpc. d) 100 (km/s)/Mpc.
   e) 118 (km/s)/Mpc.

   SUGGESTED ANSWER: (b)

Wrong answers:
c) In 1990, some folks refused to go lower than this.

Redaction: Jeffery, 2013jan01

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012 qmult 00240 1 4 1 easy deducto-memory: Hubble time and length

7. Characteristic ages and size scales for most expanding universe models are, respectively, the ____________ and the ____________.

   a) Hubble time $1/H_0$; Hubble length c/H_0 b) Hubble time c/H_0; Hubble length $1/H_0$
   c) Hubble length c/H_0; Hubble time $1/H_0$ d) Hubble time H_0; Hubble length cH_0
   e) Hubble length cH_0; Hubble time H_0

SUGGESTED ANSWER: (a)

Wrong answers:
c) Exactly wrong.
e) Everything is wrong.

Redaction: Jeffery, 2013jan01

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012 qmult 00300 1 4 3 easy deducto-memory: proper distance and luminosity distance

8. Two distance measures that arise in cosmology are ____________ and ____________.

   a) proper distance; improper distance b) improper distance; luminosity distance
   c) proper distance; proper distance d) improper distance; density distance
   e) density distance; luminosity distance

SUGGESTED ANSWER: (c)

Wrong answers:
c) Exactly wrong.
d) Everything is wrong.

Redaction: Jeffery, 2013jan01

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012 qmult 00320 1 4 2 easy deducto-memory: luminosity distance

9. Luminosity distrance is

   a) the same as proper distance in all cases.
   b) determined using the formula $r_{\rm L} = [L/(4\pi F)]^{1/2}$ in all cases if extinction is negligible.
   c) that is the length of an object undergoing FitzGerald contraction in the inertial frame of measurement.
   d) is **NOT** an improper distance.
   e) is **NOT** an improper fraction.

SUGGESTED ANSWER: (b)

Wrong answers:
b) Exactly wrong.

Redaction: Jeffery, 2013jan01

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012 qmult 00410 1 4 4 easy deducto-memory: supernovae and accelerating universe

10. What kind of supernovae provided the luminosity distances that were the first convincing evidence for the accelerating universe?

    a) Type II supernovae (SNe II). b) core collapse supernovae.
    c) Type Ib supernova (SNe Ib). d) Type Ia supernovae (SNe Ia).
    e) Type IIn supernovae (SNe IIn).

SUGGESTED ANSWER: (d)

Wrong answers:
e) Nah.

Redaction: Jeffery, 2013jan01

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012 qmult 00420 1 4 3 easy deducto-memory: supernovae and accelerating universe 2

11. Luminosity distances for Type Ia supernovae (SNe Ia) provided the first convincing evidence for the:

    a) expanding universe. b) Einstein universe. c) accelerating universe.
    d) de Sitter universe. e) big rip universe.

    SUGGESTED ANSWER: (c)

    Wrong answers:
    e) In this model, the universe expands to infinity in finite time.

    Redaction: Jeffery, 2013jan01

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012 qmult 00430 1 4 3 easy deducto-memory: light curve fitting for SNe Ia

12. Luminosity distances for Type Ia supernovae (SNe Ia) are determined by fitting ________________ for known-distance SNe Ia to ________________ for unknown-distance SNe Ia.

    a) radio emission. b) spectra. c) light curves. d) color index. e) age.

    SUGGESTED ANSWER: (c)

    Wrong answers:
    b) This is a secondary method.

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012 qmult 00500 1 4 1 easy deducto-memory: The cosmic scale factor defined

13. The proper distances between all points that participate in the mean expansion vary according to the cosmic scale factor $a(t)$ (where t is cosmic time since the Big Bang) according to the formula:

    a) $r = ar_0$. b) $r = a^2 r_0$. c) $r = a^{-2} r_0$. d) $r = a^{-1} r_0$. e) $r = e^a r_0$.

    SUGGESTED ANSWER: (a)

    Wrong answers:
    b) Nah.

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012 qmult 00560 1 4 5 easy deducto-memory: cosmic background radiation energy scaling

14. Given the energy density E of a blackbody radiation field scales as T^4 (i.e., temperature to the 4th power) and the cosmic background radiation (CBR) energy density E scales (which is a blackbody radiation field) scales as a^{-4} (where a is the cosmic scale factor), what is the formula for cosmic temperature T in terms of T_0, a_0 and a?

    a) $T = T_0(a/a_0)$ b) $T = T_0(a/a_0)^4$ c) $T = T_0(a/a_0)^2$ d) $T = T_0(a_0/a)^4$
    e) $T = T_0(a_0/a)$

    SUGGESTED ANSWER: (e)

    Wrong answers:
    b) Nah.

    Redaction: Jeffery, 2013jan01

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012 qmult 00600 1 4 1 easy deducto-memory: cosmic redshift is primary cosmic distance measure why

15. The cosmological redshift is the primary cosmic distance measure because it is:

    a) a direct observable and relatively easy to measure from **SPECTROSCOPY**.
    b) a direct observable and relatively easy to measure from **PHOTOMETRY**.
    c) an indirect observable and relatively easy to measure from **PHOTOMETRY**.
    d) an indirect observable and relatively easy to measure from **SPECTROSCOPY**.
    e) in indirect observable and relatively hard to measure from **PHOTOMETRY**.

    SUGGESTED ANSWER: (a)

    Wrong answers:

e) Everything wrong.

Redaction: Jeffery, 2013jan01

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012 qmult 00610 1 4 2 easy deducto-memory: a(t) and z related

16. The relationships between cosmological redshit z and cosmic scale factor $a(t)$ are very simple:

$$\frac{a_0}{a} = z + 1 , \qquad z = \frac{a_0}{a} - 1 , \qquad \frac{a}{a_0} = \frac{1}{z+1} .$$

So getting a/a_0 from z is easy. But we do not get $a(t)$ directly: i.e., a as a function of cosmic time t. If we did, we would know a lot more about the observable universe. It's a pity galaxies do not have big clock faces on them from which we could read cosmic time.

Now for $z >> 1$ (i.e., cosmological remote astronomical objects), we find:

a) $a/a_0 = z$. b) $a/a_0 = 1/z$. c) $a/a_0 = 1/z^2$. d) $a/a_0 = z^2$. e) $a/a_0 = 1$.

SUGGESTED ANSWER: (b)

Wrong answers:
a) Exactly wrong.

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012 qmult 00740 1 4 3 easy deducto-memory: a/a_0 at recombination

17. Given

$$\frac{a_0}{a} = z + 1 ,$$

what is the ratio a/a_0 for recombination (i.e., the recombination era of the evolution of the universe) for which $z \approx 1100$?

a) $a/a_0 \approx 1100$. b) $a/a_0 \approx 0.9 \times 10^3$. c) $a/a_0 \approx 0.9 \times 10^{-3}$. d) $a/a_0 \approx 900$.
e) $a/a_0 \approx 110$.

SUGGESTED ANSWER: (c)

Wrong answers:
a) Exactly wrong.

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012 qmult 00840 1 4 4 easy deducto-memory: dominant component of DEBRA

18. The dominant component of the diffuse extragalactic background radiation (DEBRA) is the:

a) cosmic gamma-ray background (CGB). b) cosmic X-ray background (CXB).
c) cosmic ultraviolet-optical-infrared background (CUVOIRB).
d) cosmic microwave background (CMB). e) cosmic radio background (CRB).

SUGGESTED ANSWER: (d)

Wrong answers:
e) This is the weakest well-known component.

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012 qmult 00900 1 4 1 easy deducto-memory: accelerating universe defined

19. The term accelerating universe is used to describe a cosmological model in which the rate of expansion of the universe (i.e., the rate of change of the rate of change of the cosmic scale factor $a(t)$) is:

a) increasing. b) decreasing. c) zero. d) undetermined. e) indeterminable.

SUGGESTED ANSWER: (a)

Wrong answers:
e) Arguably right too.

Redaction: Jeffery, 2013jan01

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012 qmult 00910 1 4 3 easy deducto-memory: age of universe and transition time

20. According to the Λ-CDM model (with parameter values fitted year 2018) the age of the universe is and the transition time from deceleration to acceleration is ____________.

    a) 13.8 Gyr; 6.2 Gyr b) 6.2 Gyr; 13.8 Gyr c) 13.8 Gyr; 10.02 Gyr
    d) 10.02 Gyr; 13.8 Gyr e) infinite; inapplicable.

    SUGGESTED ANSWER: (c)

    Wrong answers:
    e) This is the de Sitter universe case.

    Redaction: Jeffery, 2013jan01