Introductory Astronomy NAME:

Homework 30: Cosmology: Homeworks and solutions are posted on the course web site. Homeworks are **NOT** handed in and **NOT** marked. But many homework problems ($\sim$ 50–70 %) will turn up on exams.

1. Did you complete reading-homework-self-testing for the Introductory Astronomy Lecture (IAL) by the weekly due date?

   a) YYYessss! b) Jawohl! c) Da! d) Sí, sí. e) OMG no!

2. The science of the universe as a whole is called:

   a) proctology. b) universology. c) cosmetology. d) inflation. e) cosmology.

3. By the reckoning of almost any cosmologist, the main physics theory ingredient to cosmology is:

   a) planetary systems. b) stellar physics. c) general relativity.
   d) the quantum theory of solids. e) helioseismology.

4. Modern physical cosmology concerns itself primarily with the universe in regard to:

   a) nature of. b) purpose. c) meaning. d) mythology. e) consciousness.

5. "Let's play *Jeopardy*! For \$100, the answer is: The Pre-Socratic philosopher who proposed a universe full atoms moving in an infinite, eternal void. Occasionally, vortices formed by chance in the void. In brief, the evolution of a vortex is as follows. The vortex developed a membrane surrounding a region where an up-and-down axis developed (not necessarily aligned with the axis of rotation of the vortex). The lower part of the vortex became solid ground and ocean and the upper part air. Stars rotated with the membrane and planets (including maybe moons, and suns) moved relative to the rotation in some way. The vortex worlds or cosmoses were not eternal, they came and went. Humankind lives in a vortex cosmos with one moon, one sun, and a rotation axis not aligned with the up-and-down axis."

   Who was _____, Alex?

   a) Hesiod (circa late 8th century BCE) b) Anaximander (c.610–c.546 BCE)
   c) Socrates (c.469–399 BCE) d) Democritus (c.460–c.370 BCE)
   e) Aristarchos of Samos (c.310–c.230 BCE)

6. Given v as recession velocity and r as cosmological physical distance, Hubble's law is:

   a) $r = Hv$. b) $r = H/v$. c) $v = Hr$. d) $v = H/r$. e) $v = Hr^2$.

7. "Let's play *Jeopardy*! For \$100, the answer is: He/she is the person who observationally discovered Hubble's law."

   Who is _____, Alex?

   a) Henrietta Swan Leavitt (1868–1921) b) Knut Lundmark (1889–1958)
   c) Edwin Hubble (1889–1953) d) Georges Lemaître (1894–1966)
   e) Adriaan van Maanen (1884–1946)

8. The current value of the Hubble time and the Λ-CDM model (AKA the concordance model) value for the age of the universe are both about:

   a) 14 Gyr. b) 10^{100} yr. c) 10 years. d) 4.6 Gyr. e) 0.

9. The Hubble length is $4.283 h_{70}^{-1}$ Gpc (where h_{70} is the reduced Hubble constant: it is equal to 1 to within a few percent). It is a characteristic size scale for the:

   a) quantum of the inflaton. b) Milky Way. c) total universe. d) observable universe.
   e) Solar System.

10. The Einstein universe presented by Einstein in 1917 is a/an _____ universe model.

    a) contracting, hyperspherical b) expanding, hyperspherical c) static, hyperspherical
    d) static, hypercritical e) expanding, hypercritical

11. One of the reasons and probably the main reason for Einstein starting to do cosmology in 1917 was to add support to general relativity as a universally true theory. After all, if general relativity was a

universally true theory and gravity determines the largest scale structures of the universe, then general relativity should be able to account for the:

a) largest scale structure of the universe. b) universe in part. c) universe not at all.
d) Big Bang. e) the cosmic microwave background.

12. "Let's play *Jeopardy*! For $100, the answer is: It is an eternal, exponentially expanding cosmological model with no mass-energy content, but only a cosmological constant."

What is the _____, Alex?

a) Einstein universe (1917) b) de Sitter universe (1917) c) Lemaître universe (1931?)
d) Eddington-Lemaˆ itre universe (1925) e) Einstein-de Sitter universe (1932)

13. "Let's play *Jeopardy*! For $100, the answer is: These models were the first plausible universe models (in that they contained mass-energy) to predict the expansion of the universe."

What are the _____ models, Alex?

a) Alpher-Behte-Gamow b) Einstein-Lemaître c) Einstein d) Friedmann-equation
e) Gamow

14. "Let's play *Jeopardy*! For $100, the answer is: In the Friedmann-equation models, it is the symbol for density parameter which is the parameter that that specifies the geometry of the universe: if less than 1, the universe is hyperbolic and infinite; if equal to 1, the universe is flat and infinite; if greater than 1, the universe is hyperspherical and finite. The symbol name is often used as synonym for density parameter."

What is _____, Alex?

a) Λ (spelt Lambda) b) Ψ (spelt Psi) c) Δ (spelt Delta) d) Γ (spelt Gamma)
e) Ω (spelt Omega)

15. According to observations of several kinds beginning in 1998, it is almost certain that the universal expansion is currently:

a) decelerating. b) stopped. c) negative: i.e., the universe is contracting. d) in doubt.
e) accelerating.

16. The simplest explanation considered for the accelerating expansion of the universe is:

a) planet explosions. b) supernovae. c) stellar winds. d) green energy.
e) a cosmological constant.

17. The acceleration of the universe can most simply be accounted for by a (nonzero) cosmological constant. Alternatively, one can use a constant _____. The two are conceptionally different, but have exactly the same effect on the time evolution of the cosmic scale factor $a(t)$: i.e., they are effectively the same. Because they are effectively the same, the cosmological constant and constant _____ are often used as if they were synonyms—which is fine as long as you know what you mean.

a) dark matter b) grey matter c) dark energy d) grey energy e) dark grey

18. The Friedmann-equation Λ model (i.e., the Friedmann-equation model with a nonzero cosmological constant Λ or nonzero dark energy but still using the letter Λ since one knows what one means) with parameters adjusted to fit current observations was once often called the concordance model, but nowadays is more usually nowadays called the:

a) Λ-CDM model. b) Ω-CDM model. c) Λ-HDM model. d) Ω-HDM model.
e) discord model.

19. After the dark energy (whatever that is and assuming it's not just an effect of a true cosmological constant), the most abundant form of mass-energy in the universe is apparently some form of matter known only (at least to circa 2020) through its gravitational effects. We call this matter:

a) luminous matter. b) dark matter. c) baryonic matter. d) invisible matter.
e) mirror matter.

20. The only direct observable cosmological distance measure (except those that are only direct observables asymptotically as distances go to zero) is:

a) physical or proper distance. b) luminosity distance. c) recession velocity.
d) the cosmological redshift. e) lookback time.

21. The Big Bang, in brief, is the:

a) explosion of a supernova. b) explosion of a star. c) origin of the observable universe.
d) explosion of a quasar. e) end of the observable universe or our pocket universe.

22. In Big Bang nucleosynthesis, the two most abundant products are:

a) hydrogen and iron in about a 1:1 mass ratio. b) hydrogen and helium in about a 3:1 mass ratio. c) hydrogen and helium in about a 1:1 mass ratio. d) hydrogen and iron in about a 3:1 mass ratio. e) helium and iron in equal amounts by mass.

23. Most of the elements in the observable universe heavier than lithium were formed in:

a) stars and supernovae. b) black holes. c) the Big Bang. d) nuclear reactors.
e) planets.

24. The relic primordial electromagnetic radiation field which decoupled from matter in the recombination era circa 400,000 years after the Big Bang when hydrogen became neutral making the observable universe transparent and which has since free streamed through space and cooled off because of the expansion of the universe is called the:

a) Cosmic Gamma-ray Background (CGB). b) Cosmic X-ray Bare Ground (CXBG).
c) Cosmic X-ray Foreground (CXF). d) Cosmic Microwave Background (CMB).
e) Cosmic X-ray Background (CXB).

25. Five observational evidences are:

1. the expansion of the universe.
2. the abundances of the light elements: H, D, He, and Li.
3. the existence of the cosmic microwave background (CMB).
4. that the fluctuations in the CMB are accounted for by primordial density fluctuations that account adequately so far for the initial conditions for the large-scale structure of the universe.
5. that the oldest stars ($\gtrsim 13.6\,\mathrm{Gyr}$) are not older than the observable universe.

These evidences strongly support:

a) Big Bang cosmology. b) the steady-state universe. c) little bang cosmology.
d) the hierarchical universe. e) Democritean cosmology.

26. The Λ-CDM model is in almost all respects a very adequate cosmological model for the observable universe. But there is one major discrepancy at present. The Hubble constant measured directly from the local universe and the Hubble constant measured indirectly using the cosmic microwave background (and relying on the Λ-CDM model itself) do not agree within observational error. Either one or both measurements are wrong if the Λ-CDM model is correct. However, it seems likely that both measurements are correct, except the indirect measurement cannot actually be a measurement of the Hubble constant if they are both correct as measurements: it must be a measurement of something else. This means the Λ-CDM model probably needs to be revised perhaps to the extent that we need a new name for the revision. The disagreement in the two Hubble constant measurements is called the:

a) Hubble anomaly. b) Hubble dispute. c) Hubble-Lemaître dispute.
d) Hubble tension. e) Hubble X problem

27. "Let's play *Jeopardy*! For $100, the answer is: It is name for the super-rapid expansion that the observable universe and maybe beyond may have undergone at very early times.

What is _____, Alex?

a) inoculation b) infestation c) hybridization d) hydration e) inflation

28. "Let's play *Jeopardy*! For $100, the answer is: The popular name (among astronomers anyway) for the period in cosmological research since circa 1992."

What is the _____ of cosmology, Alex?

a) golden age b) silver age c) bronze age d) iron age e) dawn age