NAME:_____

Astronomy 350 **Fall 2012**

Final Exam
December 14, 2012

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1. DO NOT OPEN THIS EXAM UNTIL INSTRUCTED TO DO SO.
2. Show all of your work, and indicate clearly your final answer! A correct final answer may not receive credit if no work is shown.
3. Budget your time! Don't get stalled on any one question.
4. Short answer questions can be answered in 1-2 sentences, unless indicated otherwise. If you are writing paragraphs, you may have misread or misunderstood the question.
5. For your reference there are constants listed below.
6. The total number of points on the exam is 150, plus 10 possible bonus points.

Possibly Useful Information

Note that a symbol may take different meanings in different equations.

$\Delta x = v \times \Delta t$ $\quad$ $\Delta v = a \times \Delta t$

$P_{\rm yr}^2 = a_{\rm AU}^3$

$F = ma$ $\quad$ $F = Gm_1m_2/R^2$

$KE = \frac{1}{2}mv^2$ $\quad$ $PE = -Gm_1m_2/R$

$v_{\rm esc} = \sqrt{2GM/R}$ $\quad$ $M = v_{\rm circ}^2 R/G$

$F = L/4\pi R^2$ $\quad$ $d = 1 \text{ pc}/p_{\rm arcsec}$

$L \propto M^4$ $\quad$ $\tau = 10^{10} \text{ yr } (M/M_\odot)^{-3}$

$\Delta t_{\rm obs} = \Delta t_{\rm rest}/\sqrt{1 - v^2/c^2}$ $\quad$ $L_{\rm obs} = L_{\rm rest}\sqrt{1 - v^2/c^2}$

$E = mc^2/\sqrt{1 - v^2/c^2}$ $\quad$ $KE = E - mc^2$

$R_{\rm Sch} = 2GM/c^2$ $\quad$ $R_{\rm Sch,\odot} = 2GM_\odot/c^2 = 3$ km

$\Delta t_{\rm obs}/\Delta t_{\rm em} = \lambda_{\rm obs}/\lambda_{\rm em} = \sqrt{\frac{1-R_{\rm Sch}/r_{\rm obs}}{1-R_{\rm Sch}/r_{\rm oem}}}$

$z = (\lambda_{\rm obs} - \lambda_{\rm em})/\lambda_{\rm em}$ $\quad$ $v = cz$

$v = H_0 r$ $\quad$ $H = (da/dt)/a =$ rate of change in a/a

$a = 1/(1+z)$ $\quad$ $z = (1-a)/a$

$(\dot{a}/a)^2 = \frac{8\pi G}{3}\rho - \frac{K}{a^2}$ $\quad$ $\ddot{a}/a = -\frac{4\pi G}{3}(\rho + 3P/c^2)$

$\rho_{\rm crit} = \frac{3H^2}{8\pi G}$ $\quad$ $\Omega = \rho/\rho_{\rm crit}$

$\rho_{\rm matter} \propto 1/a^3$ $\quad$ $\rho_{\rm radiation} \propto 1/a^4$

$T \propto 1/a$

$G = 6.7 \times 10^{11}$ m^3/kg s^2 $\quad$ $c = 3.0 \times 10^8$ m/s

1 AU $= 1.5 \times 10^{11}$ m $\quad$ 1 pc $= 3.1 \times 10^{16}$ m $= 3.3$ lyr

1 kpc $= 10^3$ pc $=$ c $\times$ (3300 yr)

$M_\odot = 2.0 \times 10^{30}$ kg $\quad$ $M_{\rm Earth} = 6.0 \times 10^{24}$ kg

$L_\odot = 3.8 \times 10^{26}$ Watts $\quad$ $\tau_\odot = 10^{10}$ yr $= 10$ billion yrs

$H_0 = 72$ km s^{-1} Mpc^{-1}

$t_{\rm H} = 1/H_0 = 14$ billion years $\quad$ $d_{\rm H} = c/H_0 = 4200$ Mpc

$\rho_{\rm crit,0} = 10^{-29}$ g/cm^3 $\quad$ $\Omega_{\rm tot,0} = 1.02 \pm 0.2$

$\Omega_{\rm matter,0} \approx 0.3$ $\quad$ $\Omega_{\Lambda,0} \approx 0.7$

1. *The Cosmological Principle*

   (a) What does it mean for the universe to be homogeneous? Give an example of a universe that, even on large scales, is not homogeneous.

   (b) What does it mean for the universe to be isotropic? Give an example of a universe that is not isotropic.

   (c) Why is it puzzling that the universe is so isotropic? How does inflation solve this puzzle?

2. *The History of Cosmic Baryons*

   (a) What is a baryon? What is the basic composition of baryonic matter in the Sun today–that is, what the three main baryonic ingredients of the Sun today?

   (b) Trace the history of the bayonic matter that makes up the Sun, from the Early Universe to today. Be sure to **indicate the order of events**, and to mention and briefly (1–2 sentences each) explain the relevance of the following topics:
   - big bang nucleosynthesis
   - star formation and death
   - structure formation
   - baryogenesis
   - recombination