The exam will cover mostly what we discussed since the first exam. This would mostly be about our understanding of the universe in the 1900s, the characters, equipment, results. This includes the acceptance of the standard model in cosmology, cosmic microwave background, and key constituents of the universe. What were the important key ideas and moments affecting our current ideas about the origins of the universe?

1. General Relativity
   a. Spacetime
   b. Curved spacetime – flat, positive, negative
   c. Tests of general relativity (Mercury's orbit, light bending, time dilation, GPS)
   d. Expanding universe, Friedmann, Lemaitre
   e. Gravitational lensing
   f. Gravitational Waves, sources
   g. LIGO
2. Stars
   a. Stellar nucleosynthesis
   b. Fusion, fission
   c. Hydrogen, tritium, deuterium, helium, alpha particles
   d. Nuclear process in sun, proton-proton chain
3. Compact Objects
   a. Black Holes
   b. Sagittarius A$^*$, M87$^*$,Cygnus X-1
   c. Neutron Stars,
   d. White Dwarfs, discovery
   e. Chandrasekhar limit
   f. Black holes have no hair
   g. Hawking radiation
   h. Supernovae, Type Ia, Type Ib, Type II
   i. Pulsars, quasars
   j. Taylor-Hulse binary pulsar
   k. Accretion disk
4. Astronomy and Telescopes
   a. The Milky Way – size, where we live, type
   b. Harvard Computers – Williamina Fleming, Annie Jump Cannon, Henrietta Swan Leavitt
   c. The Great 1920 Debate – Shapley-Curtis
   d. George Ellery Hale, Edwin Hubble, Hubble's Law
   e. Spectroscopy and Doppler Effect (blueshift, redshift), Huggins, Slipher
   f. Wavelength, frequency, wavespeed, ( $c = f\lambda$, $d = vt$ )
   g. Electromagnetic spectrum (visible range, x-ray, radio, ultraviolet, infrared, microwave, .. )
   h. Spectroscopic work – Fraunhofer, Kirchoff, Bunsen, Balmer
   i. Radio astronomy, X-Ray astronomy, AT&T, Bell Labs
   j. Sky surveys
   k. COBE, WMAP, He balloons
5. Big Bang vs Steady State Model
   a. Gamov's soup, ylem

        b.   Gamov, Alpher, Herman, Bondi, Gold, Hoyle, Ryle
        c.   Paradigm shifts

6.   Other People
        a.   Einstein, Schwarzschild, Michell, Wheeler, Oppenheimer, Penrose, Hawking, Bekenstein
        b.   Chandrasekhar, Fowler, Zwicky, Baade, Jansky,
        c.   Dicke, Roll, Peebles, Wilkinson, Penzias, Wilson
        d.   Smoot, Mather, Schmidt

7.   Birth of Modern Cosmology
        a.   Cosmological Principle, Homogeneous, isotropic
        b.   Anthropic principle
        c.   Cepheid variables, variable stars, standard candles
        d.   Olber's Paradox
        e.   General Relativity and Cosmology – Einstein, Schwarzschild, Friedman, Lemaitre
        f.   Cosmological constant, Hubble's constant
        g.   EHT – first black hole picture
        h.   LCDM, standard cosmological model
        i.   Dark matter, dark energy, WIMPs, MACHOs