

**The First Three Minutes – Final Exam**

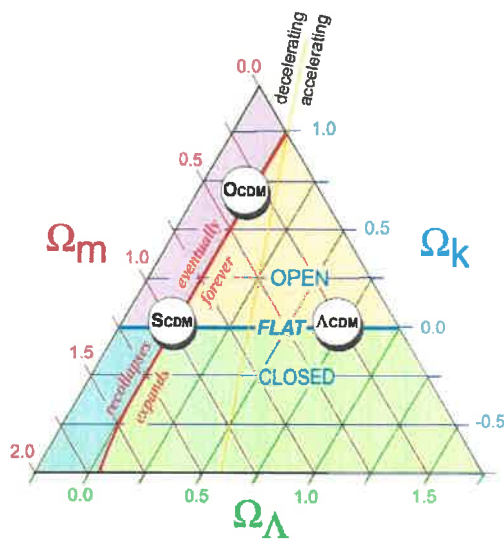
Name \_\_\_\_\_

I. (12 Pts) People Match - Find the best match and place the letter in the space provided.

A. Albert Einstein	B. Alexander Friedmann	C. Aristotle	D. Claudius Ptolemy
E. Edwin Hubble	F. Fred Hoyle	G. Johannes Kepler	H. Karl Schwarzschild
I. Max Planck	J. Nicolaus Copernicus	K. Isaac Newton	L. James Clerk Maxwell
M. Niels Bohr	N. Lois de Broglie	O. Erwin Schrodinger	P. Stephen Hawking

- a. Introduced the mathematics of the fabric of spacetime. A
- b. Predicted electromagnetic waves. L
- c. Suggested that matter can behave like waves. N
- d. Credited with 2000 yr old view of the world. C
- e. Father of classical physics. K
- f. Introduced heliocentric system. H
- g. Modeled atom as a mini solar system. M
- h. Promoted geocentric view of solar system. D
- i. Introduced spherical solution of spacetime equations. I
- j. Proponent of the steady state model. F
- k. Introduced quantization of energy. H
- l. Discovered classical planetary motion. G

II. (3 Pts) Densities – What is the below diagram called and what are the densities shown?



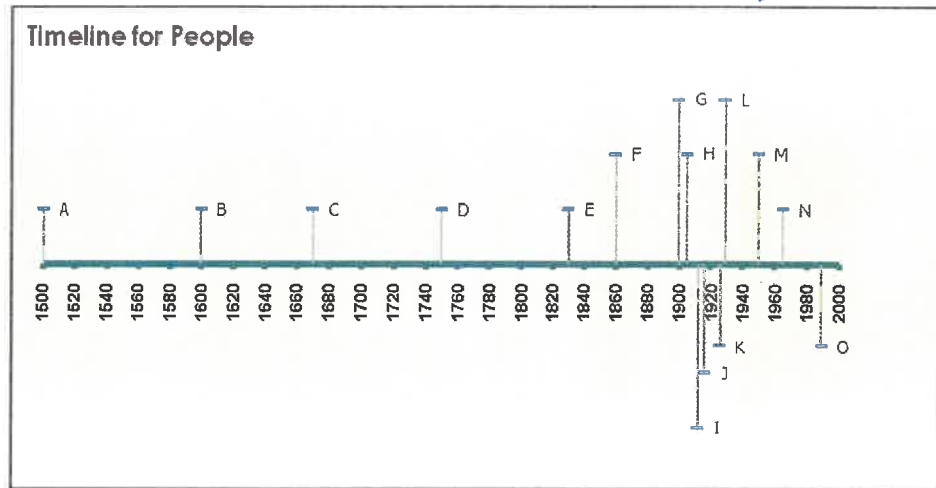
Cosmic triangle  
 Not covered in class  
 $\Omega_m$  - matter  
 $\Omega_\Lambda$  - cosmological constant  
 $\Omega_k$  - curvature

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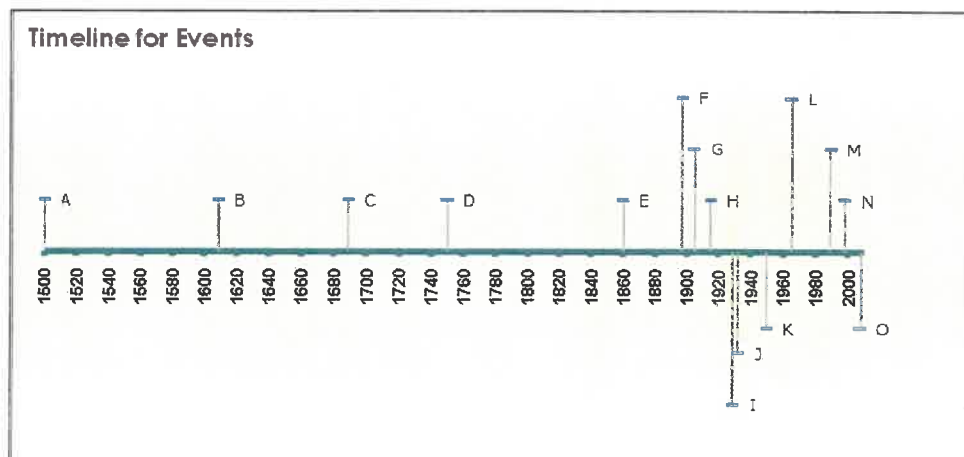
(15 Pts) People Timeline – Fill in the blank with location letter from timeline.

- |                     |                  |                             |
|---------------------|------------------|-----------------------------|
| <u>I</u> Bohr       | <u>M</u> Hoyle   | <u>Z</u> Penzias and Wilson |
| <u>A</u> Copernicus | <u>L</u> Hubble  | <u>A</u> Planck             |
| <u>H</u> Einstein   | <u>B</u> Kepler  | <u>X</u> Schrodinger        |
| <u>M</u> Faraday    | <u>F</u> Maxwell | <u>Y</u> Schwarzschild      |
| <u>D</u> Franklin   | <u>O</u> Newton  | <u>O</u> Smoot and Mather   |



III. (15 Pts) Event Timeline - Fill in the blank with location letter from timeline.

- |                                   |                                     |                                 |
|-----------------------------------|-------------------------------------|---------------------------------|
| <u>L</u> CMB Radiation Discovered | <u>D</u> Franklin's Kite Experiment | <u>C</u> Law of Gravitation     |
| <u>M</u> COBE Probe Launched      | <u>B</u> Galileo's Telescope        | <u>H</u> Neutron Discovered     |
| <u>Z</u> Dark Energy Discovered   | <u>H</u> General Relativity         | <u>A</u> Special Relativity     |
| <u>F</u> Electrons Discovered     | <u>A</u> Heliocentric Model         | <u>X</u> Steady State Model     |
| <u>E</u> EM Waves Predicted       | <u>H</u> Hubble Expansion           | <u>O</u> WMAP Last Data Release |



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IV. (12 Pts) Terms Match

Find the best match and place the letter in the space provided.

A. Dark Energy	B. Doppler Effect	C. Fission	D. Gluon
E. Higgs Boson	F. Homogeneous	G. Isotropic	H. Light Spectrum
I. Meson	J. Neutrino	K. Photon	L. Quark
M. Relativity	N. Strong Force	O. Time Dilation	P. Weak force

- a. Quantum of light. K
- b. The universe looks the same from any location. F
- c. Used to detect composition of stars. H
- d. The God Particle. E
- e. A pion is one of these. I
- f. Baryons, like protons, are made of these. L
- g. Process in the splitting of atoms. C
- h. Force holding quarks together. N
- i. Theory about space and time. M
- j. The cosmological constant is said to account for this. A
- k. Elementary particle causing quarks to interact. D
- l. Example of a lepton. J

V. (5 Pts) Numbers

- a. How old is the universe? 13.7 Gyr
- b. How many galaxies are there? 100 billion
- c. How fast does light travel in a vacuum?  $3 \times 10^8$  m/s
- d. How big is the universe? 93 billion light year diameter
- e. What is the current CMBR temperature? 2.725K

VI. (18 Pts) Short Answers – Answer all questions in sentence-paragraph form.

a. Describe two observations that support the existence of dark matter.

Gravitational lensing  
CMB anisotropies  
rotation curves

b. What is the inflationary model and what does it solve?

Not covered –  
a rapid initial (exponential) expansion  
of universe around  $10^{-36}$ s

c. How many forces are there in the current universe? What are these forces?

electromagnetic  
weak  
strong  
gravity

d. What is the breakdown in percentages of the universe into matter, normal matter, dark matter, dark energy, electromagnetic radiation, etc?

	Dark energy	68%
(cold)	Dark matter	27%
	Normal matter	~5%
	radiation	$9 \times 10^{-5}$

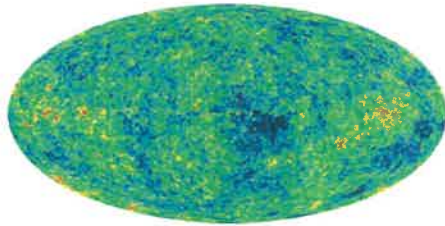
e. What was Einstein's biggest blunder?

Cosmological constant

f. What was the Steady State Model? Why is it no longer a viable theory?

The universe is constantly expanding with fixed  
matter density  
fell aside because young galaxies tend to be far away,  
and CMB

VIII. (10 Pts) What do the following pictures describe? Place your answer to the right of the picture.



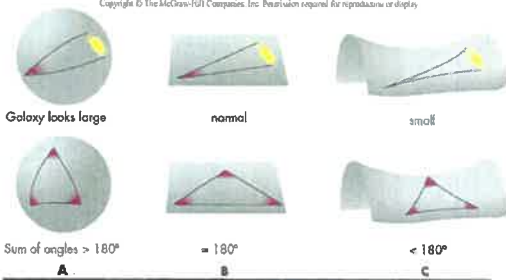
CMB

a.



Hubble expansion

b.



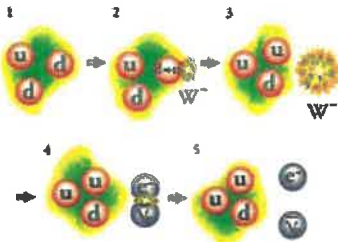
Curved spaces  
 - positive  
 - flat  
 - negative  
 angles of triangles  $> \pi, = \pi, < \pi$   
 respectively

c.



Bullet Cluster - pair of galaxies collided  
 galaxies in orange & white  
 pink - hot intracluster gas  
 Can see gravitational lensing

d.



beta decay

e.

Weak interaction - W particles  
 shows quarks (up and down)  
 electrons, antineutrinos  
 In 1. udd (neutron)  
 In 5. uud + e<sup>-</sup> +  $\bar{\nu}_e$   
 (proton)