Sample Exam type questions
to be addressed in Discussion Sections

Equations that may or may not be useful:

$F = ma; E = mc^2; T = T_o(1 + z); D = v/H_0; F = L/(4\pi D^2)$

$H_0 = \dot{R}_0/R$; $\dot{R}_0^2/R_0^2 + kc^2/R_0^2 = G8\pi\rho_0/3$

$H_0^2 + kc^2/R_0^2 = G8\pi\rho_0/3$; $dU = dQ - pdV$; $\dot{R}_0^2/R_0^2 + kc^2/R_0^2 = G8\pi\rho_0/3 + \Lambda/3$

$\rho_c = 3H_0^2/G8\pi$; $d\tau^2 = (cdt)^2 - R^2dr^2/(1 - kr^2)$

$q = \Omega_m/2 - \Omega_\Lambda$; $p \to p - c^2\Lambda/8\pi G$; $\rho \to \rho + \Lambda/8\pi G$; $dU = -pdV$

1. What are the two basic ingredients that we need to progress from the escape equation to derive the de-acceleration or acceleration of the Universe?

2. What equation above tells us a negative pressure corresponds to making it energetically favorable for the universe to expand?

3. Einstein went through several steps to be "driven" to put in a cosmological constant. Step 1. He assumed the universe as to be ____________ (hint begins with an 's."

   Step 2. Einstein then used the escape equation to derive a relationship for ____________ (hint: a Greek letter we've used in class or a word that begins with d) with the scale factor and the ____________ (of the universe, hint begins with a "c")

   Step 3. Einstein then applied the assumption that our universe is isolated to assume the equation dU= dQ-pdV can be modifed how?____________ Ordinarily we would say this is ____________ expansion, except Einstein's model didn't have expansion. Einstein then derived a relationship that demanded that either ______________ or ______________ must be negative.

   Step 4. In the end his model had k = ? the Hubble constant = ? Λ positive or negative? and the net effective pressure positive or negative?

   How can we see for the matter dominated era that Einstein's inclusion of a cosmological constant leads to an effective repulsive force?

   In the end, how did Einstein's model prevent expansion?

4. What is the formula that relates q to Ω_m (with no Ω_Λ in the formula)? ______________.. What is the value of q for an "empty" flat universe (hint now Λ is non-zero)? ______________ This value then leads to our saying the universe would be accelerating or de-accelerating (which and why?) What is difference between the physical meaning of Ω_m and q.

5. Starting from today and going backward in time, the geometry of the universe tends toward what shape? for (a) a flat universe, (b) an open universe, and (b) a closed universe This then argues that Ω tend to what value?

6. Draw curves of R(t) versus t (starting from t = 0) for a few cases: , (a) $\dot{R} = 0$, (b) R = ct (c) a closed universe for the case with $\Lambda = 0$, (d) A Lemaitre universe.

7. What is a predicted "observable" for a Lemaitre universe (at least as discussed in class)

   (a) That there are 10^{11} stars in our galaxy. (b) That there are about 10^9 galaxies in the the observable universe. (c) That we should find objects in the sky have mirror images 180 degrees away. (d) That we should find that the velocity which the earth travels around the center of our galaxy is 250 km/sec

8. Discuss entropy and the the question of the big crunch versus the big bounce, the relationship between entropy, the arrow of time and energy density.

9. Tell how the Hubble constant can be used to estimate age of the universe (hint a dimensional argument is OK) and how the value of Ω_m (in the case where $\Omega_\Lambda = 0$) *for a fixed observed value of the Hubble constant* affects the value we derive? Hint: draw R(t) versus t and remember that H = the slope to R(t). So which value of Ω_m allows R(t) curve to become relatively "flat" or small slope value more quickly?