Definitions, results, etc.

* $r = R(t)\ \varpi$

* $H = \frac{1}{R}\frac{dR}{dt}$

*Densities:

Matter: $\rho_m = \rho_{o,m} R^{-3}$

Radiation: $\rho_r = \rho_{o,r} R^{-4}$

Dark energy: $\rho_\Lambda = \rho_{o,\Lambda} R^{0}$

$$\rho_c(t) = \frac{3H^2(t)}{8\pi G}$$

$$\Omega(t) = \frac{\rho(t)}{\rho_c(t)}$$

$$\Omega \equiv \Omega_m + \Omega_{\rm rel} + \Omega_\Lambda$$

Temp. of radiation field: $T_0 = RT(R)$ *

$$\frac{d(R^3\rho)}{dt} = -\frac{P}{c^2}\frac{d(R^3)}{dt}$$

$$q(t) = -\frac{R(t)\,[d^2R(t)/dt^2]}{[dR(t)/dt]^2}$$

* $P = wu = w\rho c^2$

Physics

Per unit mass:

K.E. + potential E. = Total Energy

$$\left(\left(\frac{1}{R}\frac{dR}{dt}\right)^2 - \frac{8}{3}\pi G\rho\right) R^2 = -kc^2$$

$\rho = \frac{u}{c^2}$ *

* $$(ds)^2 = (c\,dt)^2 - R^2(t)\left[\left(\frac{d\varpi}{\sqrt{1-k\varpi^2}}\right)^2 + (\varpi\, d\theta)^2 + (\varpi \sin\theta\, d\phi)^2\right]$$

* $$\left[\left(\frac{1}{R}\frac{dR}{dt}\right)^2 - \frac{8}{3}\pi G\rho - \frac{1}{3}\Lambda c^2\right] R^2 = -kc^2$$

Cosmological Constant (a.k.a. *Dark Energy*)

Curvature $k = \frac{1}{R_o^2}$ x +1, 0, -1

$dU = -PdV$ *

$$\frac{d^2R}{dt^2} = \left\{-\frac{4}{3}\pi G\left[\rho_m + \rho_{\rm rel} + \frac{3(P_m + P_{\rm rel})}{c^2}\right] + \frac{1}{3}\Lambda c^2\right\} R$$

* = you should be able to write these down from memory.