Problems Class 0

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Equations and constants

The Friedmann Equation:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3c^2}\varepsilon - \frac{\kappa c^2}{R_0^2}\frac{1}{a^2}$$

The Fluid Equation:

$$\dot{\varepsilon} + 3\frac{\dot{a}}{a}(\varepsilon + P) = 0$$

Cosmological parameter values in The Benchmark Model:

$$\Omega_{M,0} = 0.31,\ \Omega_{D,0} = 0.69,\ \Omega_{R,0} = 9 \times 10^{-5},\ H_0 = 67.7 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

Constants: 1 pc $= 3.09 \times 10^{16}$ m; $m_p = 1.67 \times 10^{-27}$ kg; 1 eV $= 1.6 \times 10^{-19}$ J

Questions

1. Convert 1 km s^{-1} Mpc^{-1} into units of years^{-1}.
2. The density of interplanetary space is around 5 particles per cubic centimeter. Assuming all these particles are protons (they're not), what is the density of interplanetary space in units of MeV m^{-3}?
3. Differentiate $\dot{x}^2$ with respect to time.
4. Solve $\dot{x}/x = C$, where C is a constant, to get an expression for $x(t)$.
5. Using the answer from the previous question, calculate

$$y = \int_{x=1}^{x=2} \frac{dt}{x(t)} \tag{1}$$

giving your answer in terms of C.