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## Physics 3710 – Problem Set #1

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Problems 1-5 refer to the first figure in BK1.

1. For the  $\log_{10}(\text{time/s})$  scale in the figure some interval starts at  $x$  and ends at  $y$ . Assume both  $x$  and  $y$  are integers (positive, negative, or zero). *Approximately* how long is the interval in seconds?
2. What would  $\log_{10}(\text{time/s})$  be for the “Big Bang” ( $t = 0$  s).
3. On a log-log plot a power law function  $y = Ax^p$  is a straight line with slope  $p$ . (That is,  $\log(y) = p \log(x) + \log(A)$ . It doesn't matter what the base of the logarithm is.) The figure shows that  $\log_{10}(\text{energy/eV})$  is approximately linear in  $\log_{10}(\text{time/s})$  for both the matter and radiation dominated epochs, but with slightly different slopes. If you draw straight lines through the matter and radiation curves on the figure in BK1, you get roughly the following sets of points on the lines: for matter (12, 0.5) and (15, -1.5); for radiation (-28, 20) and (10, 1). Determine  $p$  in each case assuming it is a simple rational fraction.
4. The smallest “physical” time mentioned in BK1 is the so-called *Planck time*,  $t_p$ . The Planck time is a combination of gravity, relativity, and quantum mechanics, of the form  $t_p = G^x c^y \hbar^z$  where  $x$ ,  $y$ , and  $z$  are dimensionless constants. If  $M$ ,  $L$ , and  $T$  are the fundamental dimensions “mass,” “length,” and “time,” respectively, the fundamental dimensions of  $G$  are  $M^{-1}L^3T^{-2}$ , of  $c$  are  $L^1T^{-1}$ , and of  $\hbar$  are  $M^1L^2T^{-1}$ . Show that  $x = z = 1/2$  and  $y = -5/2$ .
5. Using the results of Problem 4, insert the values of  $G$ ,  $c$ , and  $\hbar$  in SI units and show that for  $t_p$   $\log_{10}(\text{time/s}) \approx -43$ .