PH 306
Nuclear Science and Engineering
Total marks: 10

Department of Physics
IIT Guwahati
Assignment-I

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1. Discuss the inertial confinment technique used in nuclear fusion reactions.
   (Give your answer in terms of 10-15 points, with brief mathematics as required. Maximum length one A4 size page).

2. What is phase stability and how it can be achieved in particle accelerators.
   (Give your answer in terms of 10-15 points, with brief mathematics as required. Maximum length one A4 size page).

3. Give the quark content of hadrons given below (e.g. proton = p(u,u,d))
   (a) Hadrons : (p,n), $(\Sigma^+, \Sigma^0, \Sigma^-)$, $(\Delta^{++}, \Delta^+, \Delta^0, \Delta^-)$ and Ω^-
   (b) Mesons : (π^+, π^0, π^-), (K^+, K^0) and (D^+, D^0).

4. (a) Define what is Strangeness (the Strange quantum number) and give its value for each of the above hadrons.
   (b) Arrange these hadrons given above in the Isospin multiplets and specify both the Isospin and the third component I_3 of the Isospin for each of the above hadrons.

5. Using the four vector notation, calculate $F_{\mu\nu}\ F^{\mu\nu}$ in terms of the time and spatial derivatives of the electirc scalar and magnetic vector potentials. Here, $F_{\mu\nu}$ is the field strength tensor.

6. For a $2 \to 2$ process given in terms of their four momenta $p_1 + p_2 = p_3 + p_4$ (where incoming particles are massless $m_1 = m_2 = 0$ and outgoing particles are massive $m_3 = m_4 = m$), calculate the following in terms of the angle θ between $\vec{p_1}$ and $\vec{p_3}$:
   (a) $s = (p_1 + p_2)^2$
   (b) $t = (p_1 - p_3)^2$
   (c) $u = (p_1 - p_4)^2$
   (d) M2 $= \frac{(t^2+u^2)}{s^2}$.

   (Hint : For the above question, first write the individual components of each of the four vectors p_1, p_2, p_3, p_4. It can be assumed that the entire scattering phenomenon to occur in xz- plane, and z-axis can be taken as the direction of the incoming particles.)

$$x^\mu = (ct, \vec{x}) \text{ and } x_\mu = (ct, -\vec{x})$$
$$\partial_\mu = \frac{\partial}{\partial x^\mu} = (\frac{\partial}{c\partial t}, \vec{\nabla}), \partial^\mu = \frac{\partial}{\partial x_\mu} = (\frac{\partial}{c\partial t}, -\vec{\nabla})$$
$$A^\mu(x) = (\phi(x)/c, \vec{A}(x))$$
$$F_{\mu\nu} = (\partial_\mu A_\nu - \partial_\nu A_\mu)$$