Name and Surname:
Student ID:

1. What are the following concepts?
   (a) 4-vector
   (b) SU(N), SO(N), SO(3,1)
   (c) on-shell/off-shell
   (d) Boson/Fermion
   (e) Symmetry
   (f) Clebsch-Gordan coefficients
   (g) Isospin
   (h) Charge conjugations symmetry
   (i) Time reversal symmetry
   (j) Parity Symmetry
   (k) Cross Section
   (l) Decay Width
   (m) scalar meson/vector meson
   (n) CP Violation
   (o) pion, K-meson
   (p) semi-leptonic decay
   (q) hadronic decay
   (r) Gauge Symmetry
   (s) Renormalization
   (t) Dimensional analysis
   (u) Dimensional regularization
   (v) Selection Rules (in QM)
   (w) Noether's current
   (x) Gauge theory
   (y) particle resonance
   (z) invariant mass of the lepton pair in the decay $B \to K\ell^+\ell^-$

2. What are the eigen-energies of a particle trapped in an infinite potential well of width L.

3. What are the Pauli matrices? (Write down their expression and explain how they are used)

4. What is the particle content of the Standard Model?

5. How is the force described in our present understanding of particle physics?

6. What interactions are described by the standard model?

7. Consider the two-body decay $A(p+q) \rightarrow B(p) + C(q)$ where the letter in paranthesis denote the four momenta of the particles. Using four vector notation, show that if A is massless and B and C are massive, this decay is kinematically forbidden.

8. Calculate the cross-section for the $e^+e^- \rightarrow \mu^+\mu^-$ scattering.

9. Given the four vectors

$$\begin{aligned} e_1 &= (1,0,0,1) \\ e_2 &= (1,0,0,-1) \\ e_3 &= (0,1,i,0) \\ e_4 &= (0,1,-i,0) \end{aligned} \tag{1}$$

   calculate the matrix M whose (i,j) element is given by $e_i^* \cdot e_j$

10. Write down the Dirac and Klein Gordon equations. What is the equation satisfied by a massive vector particle?

11. In the Born approximation, calculate the scattering amplitude of an electron off a nucleus of electric charge Ze (assume that the nucleus is infinitely heavy.)

12. Calculate the integral $\int_{-\infty}^{\infty} dx e^{-x^2}$. (Show your steps)

13. Calculate the following trace: $Tr\gamma_\mu\gamma_\nu\gamma_\alpha\gamma_\beta$