Enunciados + CAPTURA PANTALLA

Capitulo 1: Física de particulas y relatividad especial

1. A quantum fi eld

- (a) Is a fi eld with quanta that are operators
- (b) Is a fi eld parameterized by the position operator
- © Commutes with the Hamiltonian
- (d) Is an operator that can create or destroy particles

2. The particle generations

- (a) Are in some sense duplicates of each other, with each generation having increasing mass
- (b) Occur in pairs of three particles each
- © Have varying electrical charge but the same mass
- (d) Consists of three leptons and three quarks each

3. In relativistic situations

- (a) Particle number and type is not fi xed
- (b) Particle number is fi xed, but particle types are not
- © Particle number can vary, but new particle types cannot appear
- (d) Particle number and types are fi xed

4. In quantum fi eld theory

- (a) Time is promoted to an operator
- (b) Time and momentum satisfy a commutation relation
- © Position is demoted from being an operator
- (d) Position and momentum continue to satisfy the canonical commutation relation

5. Leptons experience

- (a) The strong force, but not the weak force
- (b) The weak force and electromagnetism
- © The weak force only
- (d) The weak force and the strong force

6. The number of force-carrying particles is

- (a) Equivalent to the number of generators for the fi elds gauge group
- (b) Random
- © Proportional to the number of fundamental matter particles involved in the interaction
- (d) Proportional to the number of generators minus one

7. The gauge group of the strong force is:

- (a) SU(2)
- (b) U(1)
- © SU(3)
- (d) SU(1)

8. Antineutrinos

- (a) Have charge -1 and lepton number 0
- (b) Have lepton number +1 and charge 0
- © Have lepton number -1 and charge 0
- (d) Are identical to neutrinos, since they carry no charge

Soluciones 1: Física de particulas y relatividad especial

- 1. d
- 2. a
- 3. a
- 4. c
- 5. b
- 6. a
- 7. c
- 8. c
- 9. c
- 10. d

Capitulo 2: Teoría de campos lagrangiana

Quiz

1. Find the equation of motion for a forced harmonic oscillator with Lagrangian

$$L = \frac{1}{2}m\dot{x}^2 - \frac{1}{2}m\omega^2 x^2 + \alpha x$$

Here α is a constant.

2. Consider a Lagrangian given by

$$\mathcal{L} = -\frac{1}{2}\partial_\mu\varphi\partial^\mu\varphi - \frac{1}{2}m^2\varphi^2 - V(\varphi)$$

(a) Write down the field equations for this system.

(b) Find the canonical momentum density $\pi(x)$.

(c) Write down the Hamiltonian.

3. Consider a free scalar field with Lagrangian $\mathcal{L} = \partial_\mu\varphi\partial^\mu\varphi$ and suppose that the field varies according to $\varphi \to \varphi + \alpha$, where α is a constant. Determine the conserved current.

4. Refer to the Lagrangian for a complex scalar field Eq. (2.37). Determine

Soluciones 2: Teoría de campos lagrangiana

Chapter 2

1. $\frac{d^2x}{dt^2}+\omega^2x=-\frac{\alpha}{m}$

2. (a) $\partial_\mu\partial^\mu\varphi-m^2\varphi=\frac{\partial V}{\partial\varphi}$

   (b) $\pi=\dot{\varphi}$

   (c) $H=\int d^3x\left(\frac{1}{2}\pi^2+\frac{1}{2}(\nabla\varphi)^2+\frac{1}{2}m^2\varphi^2+V(\varphi)\right)$

3. $J^\mu=\partial^\mu\varphi$

4. Each field separately satisfies a Klein-Gordon equation, that is, $\partial_\mu\partial^\mu\varphi+m^2\varphi=0$, $\partial_\mu\partial^\mu\varphi^\dagger+m^2\varphi^\dagger=0$. To get this result apply Eq. (2.14) to the Lagrangian Eq. (2.37).

5. $Q=i\int d^3x\left(\varphi^\dagger\frac{\partial\varphi}{\partial t}-\varphi\frac{\partial\varphi^\dagger}{\partial t}\right)$

6. The action is invariant under that transformation.

Capitulo 3: Una Introducción a la teoría de grupos

Quiz

1. Consider an element of $SU(2)$ given by $U = e^{i\sigma_x \alpha/2}$. By writing down the power series expansion, write U in terms of trigonometry functions.
2. Consider $SU(3)$ and calculate $tr(\lambda_i \lambda_j)$.
3. How many casimir operators are there for $SU(2)$?
4. Write down the casimir operators for $SU(2)$.

   A Lorentz transformation can be described by boost matrices with rapidity defined by $\tanh\phi = v/c$. A boost in the x direction is represented by the matrix

$$\begin{pmatrix} \cosh\phi & \sinh\phi & 0 & 0 \\ \sinh\phi & \cosh\phi & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

5. Find the generator K_x.

Soluciones 3: Una Introducción a la teoría de grupos

Chapter 3

1. $U = \cos\alpha + i\sigma_x \sin\alpha$
2. $2\delta_{ij}$
3. 1
4. Try $\vec{\sigma}^2 = \sigma_x^2 + \sigma_y^2 + \sigma_z^2$
5. $K_x = -i\begin{pmatrix} 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$
6. $K_y = -i\begin{pmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$

7. No, because the algebra among the generators requires the introduction of the angular momentum operators. Therefore, Lorentz transformations together with rotations form a group.

Capitulo 4: Simetrías discretas y números cuánticos

Quiz

1. Angular momentum states transform under the parity operator as
   (a) $P|L,m_z\rangle = -|L,m_z\rangle$
   (b) $P|L,m_z\rangle = L|L,m_z\rangle$
   (c) $P|L,m_z\rangle = (-1)^L|L,m_z\rangle$
   (d) $P|L,m_z\rangle = |L,m_z\rangle$
2. The interaction Lagrangian of electromagnetism is invariant under charge conjugation if
   (a) $CA^\mu C^{-1} = -A^\mu$
   (b) It is not invariant under charge conjugation
   (c) $CJ^\mu C^{-1} = J^\mu$
   (d) $CA^\mu C^{-1} = A^\mu$
3. Parity is
   (a) Conserved in weak and electromagnetic interactions, but is violated in the strong interaction
   (b) Conserved in strong interactions, but is violated in weak and electromagnetic interactions
   (c) Not conserved
   (d) Conserved in the strong and electromagnetic interactions, but is violated in the weak interaction

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Soluciones 4: Simetrías discretas y números cuánticos

- 1. c
- 2. a
- 3. d

- 4. a
- 5. c

Capitulo 5: La ecuación de Dirac

Quiz

1. Given the Lagrangian

$$\mathcal{L} = \bar{\psi}(x)[i\gamma^{\mu}\partial_{\mu} - m]\psi$$

vary $\psi(x)$ to find the equation of motion obeyed by $\bar{\psi}(x)$.

2. Calculate $\{\gamma_5, \gamma^{\mu}\}$.
3. Consider the solution of the Dirac equation with $E = \omega_k > 0$. Find a relationship between the u and v components of the Dirac field.
4. Find the normalization of the free space solutions of the Dirac equation using the density $\bar{\psi}\gamma^0\psi$.
5. Find S^{01}, the generator of a boost in the x direction.
6. We can introduce an electromagnetic field with a vector potential A_{μ}. Let the source charge be q. Using the substitution $p_{\mu} \to p_{\mu} - qA_{\mu}$, determine the form of the Dirac equation in the presence of an electromagnetic field.

Soluciones 5: La ecuación de Dirac

Chapter 5

1. $i\frac{\partial\bar{\psi}}{\partial x^{\mu}}\gamma^{\mu}+m\bar{\psi}$
2. 0
3. $v=\frac{\vec{k}\cdot\vec{\sigma}}{\omega_k+m}u$
4. $\psi(0)=\sqrt{2m}\begin{pmatrix}u\\v\end{pmatrix}$
5. $-\frac{i}{2}\begin{pmatrix}\sigma_1 & 0\\0 & -\sigma_1\end{pmatrix}$
6. $\gamma^{\mu}(i\partial_{\mu}-qA_{\mu})\psi-m\psi=0$

Capitulo 6: Campos escalares

Quiz

1. Given the Lagrangian

$$\mathcal{L}=\bar{\psi}(x)[i\gamma^{\mu}\partial_{\mu}-m]\psi$$

vary $\psi(x)$ to find the equation of motion obeyed by $\bar{\psi}(x)$.

2. Calculate $\{\gamma_5,\gamma^{\mu}\}$.
3. Consider the solution of the Dirac equation with $E=\omega_k>0$. Find a relationship between the u and v components of the Dirac field.
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Soluciones 6: Campos escalares

Chapter 6

1. 0
2. $[n(\vec{k})+1]\hat{a}^{\dagger}(\vec{k})\big|n(\vec{k})\big\rangle$
3. 0
4. $[H,Q]=0$

Capitulo 7: Las reglas de Feynman

Quiz

1. What is the amplitude for the process shown in Fig. 7.16?

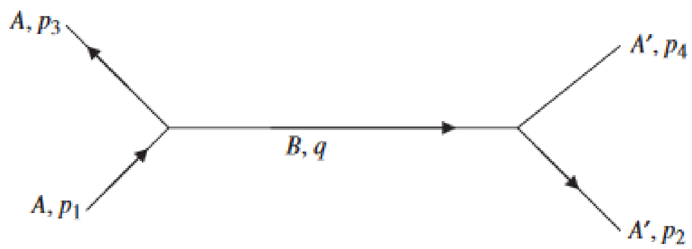

Figure 7.16 Feynman diagram for Question 1.

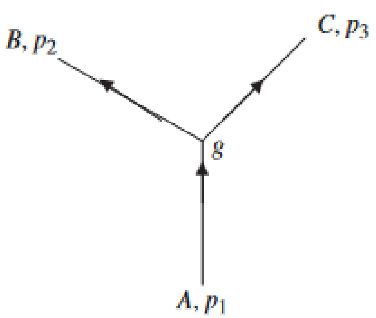

Figure 7.17 Feynman diagram for Question 1.

Figure 7.17 Feynman diagram for Question 1.

2. Find the lifetime for the decay as shown in Fig. 7.17.
3. An internal line corresponds to a spin-0 boson of mass m. The propagator is
   (a) $i\dfrac{q+m}{q^2-m^2}$
   (b) $\dfrac{i}{q^2-m^2}$
   (c) $\dfrac{i}{q-m}$
   (d) $\delta(q^2-m^2)$
4. In the interaction picture,
   (a) The time evolution of states is governed by the free Hamiltonian
   (b) States are stationary, operators evolve according to the interaction part of the Lagrangian
   (c) States evolve according to the interaction part of the Hamiltonian, fields evolve according to the free part of the Hamiltonian
   (d) States obey the Heisenberg equation of motion
5. Each vertex in a Feynman diagram requires the addition of
   (a) One factor of the coupling constant $-ig$
   (b) One factor of the coupling constant $-g$

Capitulo 8: Electrodinámica cuántica

Quiz

1. Compute $[D_\mu, D_\nu]$.
2. The Lagrangian of quantum electrodynamics can be best described as
   (a) Admitting a local $U(1)$ symmetry
   (b) Admitting a global $U(1)$ symmetry
   (c) Admitting a local $SU(2)$ symmetry
   (d) Admitting a local $SU(1)$ symmetry
3. Write down the amplitude for electron-positron scattering as shown in Fig. 8.11.

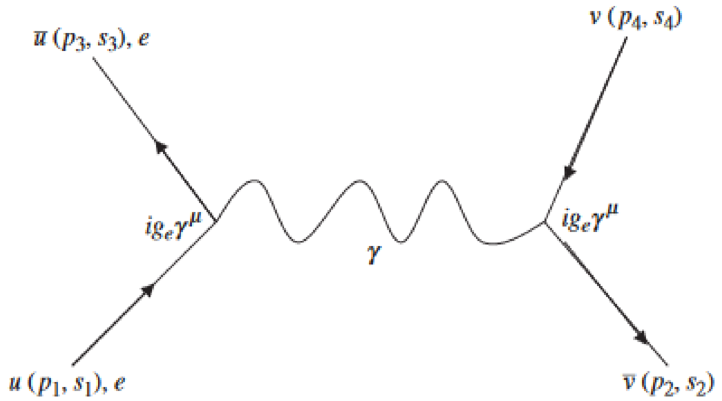

Figure 8.11 Electron-muon scattering to lowest order.

4. The minimal coupling prescription for the QED Lagrangian is
   (a) $D_\mu = \partial_\mu + ie A_\mu$

4. The minimal coupling prescription for the QED Lagrangian is
   (a) $D_\mu = \partial_\mu + ig_e A_\mu$
   (b) $D_\mu = \partial_\mu - ig_e A_\mu$
   (c) $D_\mu = \partial_\mu + iqA_\mu$
   (d) $D_\mu = \partial_\mu + iq\gamma^\mu A_\mu$
5. In a QED process an incoming antiparticle state is written as
   (a) $\bar{v}(p,s)$
   (b) $\bar{u}(p,s)$
   (c) $u(p,s)$
   (d) $v(p,s)$

Soluciones 7 y 8

Chapter 7

1. $-i\dfrac{g^2}{(p_2 - p_4)^2 - m_B^2}$
2. $\dfrac{1}{g^2}$
3. b
4. c
5. a
6. $\alpha = 1/137$

Chapter 8

1. $iqF_{\mu\nu}$
2. a
3. $-g_e^2[v(k')\gamma^\mu \bar{v}(k)]\dfrac{g_{\mu\nu}}{(p-p')^2}\bar{u}(p')\gamma^\mu u(p)$
4. c
5. a