Short HW 3: **Indices**

Course: Physics 165, *Introduction to Particle Physics* (2018)
Instructor: Prof. Flip Tanedo (flip.tanedo@ucr.edu)
Due by: **Thursday**, January 18

Note that this short assignment is due in class on Thursday. You have only *two days* to do it. This should be quick, I recommend doing it right after class on Tuesday.

1 The Yukawa interaction

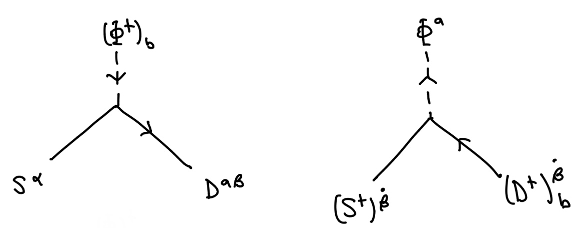
Consider the following toy theory of spin-1/2 particles interacting with a spin-0 particle. The theory has an SU(2) symmetry with doublet indices $a, b, c, \cdots \in \{1, 2\}$ and triplet indices $A, B, \cdots \in \{1, 2, 3\}$. You have the following tensors:

- Lorentz metrics: metric for vectors ($\eta^{\mu\nu}$, $\eta_{\mu\nu}$), metric for spinors ($\varepsilon^{\alpha\beta}$, $\varepsilon_{\alpha\beta}$, $\varepsilon^{\dot{\alpha}\dot{\beta}}$, $\varepsilon_{\dot{\alpha}\dot{\beta}}$)
- Lorentz tensor: σ-matrices ($\sigma^{\mu}{}_{\alpha\dot{\beta}}$)
- SU(2) metrics: ϵ_{ab}, ϵ^{ab}, δ_{AB} (i.e. you can contract two upper A indices)
- SU(2) tensors: f^{abc}, $T^{Aa}{}_{b}$
- The identity: δ^a_b, δ^α_β, etc.
- Momenta: p^μ of any particle going into the vertex

You have the following particles:

Here Φ^a is an SU(2) doublet, meaning it has two components. It has an anti-particle, $(\Phi^\dagger)_b$. Observe that Φ is a Lorentz scalar: it doesn't have any spinor or vector index. The particle S is a spin-1/2 particle that is an SU(2) singlet ("SU(2) scalar"), it has a spinor index but does not have any SU(2) indices. It has an antiparticle $(S^\dagger)^{\dot{\beta}}$ The particle D is an SU(2) doublet and a spin-1/2 particle with spinor indices. It has an anti-particle $(D^\dagger)^{\dot{\beta}}{}_b$.

Show that you can write down the following Feynman rules:



That is, for each proposed Feynman rule, write down an invariant using the tensors above and the particles. For example, your answer for the first diagram should look like:

$$S^\alpha (\Phi^\dagger)_b D^{a\beta} \left[\text{some combination of tensors}\right]^b{}_{\alpha\beta a}$$

Remarks: Don't confuse a and α. The S has no arrow because it carries no charge.