1. Back to monopoles one more time. Please read the class notes (for week 11), in which I have completed the discussion of these and corrected the constants in the derivation, or if you prefer, read Jackson’s discussion in section 6.12.

Consider a system containing two point particles of charges $q = (q_e, q_m)$ and $q' = (q'_e, q'_m)$ respectively, at rest a distance $d$ from each other.

(a) Write the electric and magnetic fields for this configuration. No fancy expansion or manipulation needed here, just write down the fields by superposing the fields of each of the two particles.

(b) Find the total momentum in the fields of one dyon (recall a dyon is a particle with both electric and magnetic charges). Why is this result to be expected?

(c) Find the total momentum $P$ in the fields you wrote in (a). You may worry about divergences here but these will not in fact be a problem; use the results of (b).

(d) Repeat parts (b) and (c) for the total angular momentum in the fields.

(e) In quantum mechanics, as you know, rotations are generated by the angular momentum operator. Under a rotation by an angle $\alpha$ about an axis $\hat{n}$, the wavefunction transforms by

$$\psi \rightarrow e^{-i\alpha L \cdot \hat{n}/\hbar} \psi.$$ 

If we assume our particles are scalar (spinless) particles so that there is no additional factor from their internal rotational properties, rotations simply act by moving the particles around each other and we expect $\psi$ to be invariant under rotations by $2\pi$ about any axis (single-valued). What condition does this imply on the charges $q$ and $q'$? How does this condition change when one of the two particles is a spinor, whose wavefunction changes sign under a rotation by $2\pi$?

2. (Jackson, 7.2)
3. (Jackson 7.5)

4. (Jackson 7.23)

5. (Jackson 7.24)