

Physics 564, Spring 2025
Homework assignment 5
Due Tuesday, 25 March

Remember that your homework solutions must contain a description of what you are doing, and *not* just a list of equations.

1. **Spin 1:** In class, we were able to construct $|\uparrow\rangle_y$ in the z -basis two different ways:
 - By using the representation of J_y operator in the z -basis and find the eigenvectors in the usual way.
 - By rotating $|\uparrow\rangle_z$ ket about the x -axis.

In this problem, I want you to repeat the process for a $s = 1$ particle (such as the famous J/ψ meson with quark content $c\bar{c}$).

- (a) Write down the matrix operators S_+ and S_- in the z -basis. Do show some of how/why you got those answers!
- (b) Say a particle is in the $s_z = 0$ eigenstate. What is this state in the s_y basis? I.e. find a , b , and c in

$$|s_z = 0\rangle = a|s_y = 1\rangle + b|s_y = 0\rangle + c|s_y = -1\rangle$$

by using the method of representing the S_y in the z -basis.

- (c) Now, repeat the process by rotating the $|s_z = 0\rangle$ state.
- (d) Compare your results: do they agree (they better!), and does the result make sense given that spin-1 particles are considered vectors (think to how vectors rotate - a topic we discussed at length when developing all of this)?

2. **Pauli matrices as a vector:** In class, we talked a lot about the Pauli matrices:

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

Show that these quantities are actually the components of a vector.

$$\vec{\sigma} = \sigma_x \hat{x} + \sigma_y \hat{y} + \sigma_z \hat{z}$$

Hint: vectors are defined in terms of their properties under rotation. I don't need a general proof, a single rotation is sufficient.

Another Hint: Operators/Matrices do not transform like simple columns!

3. *Griffiths* 4.33
4. *Griffiths* 4.37
5. *Griffiths* 4.40

Also, do not forget that you can also turn in your next metacognitive exercise that same day.