

PHYSICS 439: QUANTUM MECHANICS II  
PROBLEM SET 10: ANGULAR MOMENTUM AND SPIN

1. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the components of the angular momentum operator,  $L_x$ ,  $L_y$ , and  $L_z$ .

2. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the squares of the components of the angular momentum operator,  $L_x^2$ ,  $L_y^2$ , and  $L_z^2$ .

3. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the products of the components of the angular momentum operator,  $L_x L_y$ ,  $L_y L_x$ ,  $L_x L_z$ , and  $L_z L_x$ .

4. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the commutators of the components of the angular momentum operator,  $[L_x, L_y]$ ,  $[L_y, L_z]$ , and  $[L_z, L_x]$ .

5. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the commutators of the squares of the components of the angular momentum operator,  $[L_x^2, L_y^2]$ ,  $[L_y^2, L_z^2]$ , and  $[L_z^2, L_x^2]$ .

6. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the commutators of the products of the components of the angular momentum operator,  $[L_x L_y, L_z]$ ,  $[L_y L_x, L_z]$ ,  $[L_x L_z, L_y]$ , and  $[L_z L_x, L_y]$ .

7. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the commutators of the products of the squares of the components of the angular momentum operator,  $[L_x^2 L_y^2, L_z]$ ,  $[L_y^2 L_z^2, L_x]$ , and  $[L_z^2 L_x^2, L_y]$ .

8. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the commutators of the products of the commutators of the components of the angular momentum operator,  $[L_x, L_y, L_z]$ ,  $[L_y, L_z, L_x]$ , and  $[L_z, L_x, L_y]$ .

9. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the products of the commutators of the components of the angular momentum operator,  $[L_x, L_y] L_z$ ,  $[L_y, L_z] L_x$ , and  $[L_z, L_x] L_y$ .

10. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the products of the commutators of the squares of the components of the angular momentum operator,  $[L_x^2, L_y^2] L_z$ ,  $[L_y^2, L_z^2] L_x$ , and  $[L_z^2, L_x^2] L_y$ .

11. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the products of the commutators of the products of the components of the angular momentum operator,  $[L_x, L_y, L_z, L_x]$ ,  $[L_y, L_z, L_x, L_y]$ , and  $[L_z, L_x, L_y, L_z]$ .

12. A particle is in a state  $Y_{lm}$  with angular momentum quantum number  $l$  and magnetic quantum number  $m$ . Calculate the expectation values of the products of the commutators of the products of the squares of the components of the angular momentum operator,  $[L_x^2, L_y^2, L_z^2]$ ,  $[L_y^2, L_z^2, L_x^2]$ , and  $[L_z^2, L_x^2, L_y^2]$ .