PHYS 20323/60323: Fall 2024 - LaTeX by: Ella June Thessen:D

1. An electron is found to be in the spin state (in the z-basis) $\chi = A\begin{pmatrix} 3i \\ 4 \end{pmatrix}$

   (a) (5 points) Determine the possible values of A such that the state is normalized.

   (b) (5 points) Find the expectation values of the operators S_x,S_y, S_z, and $\vec{S}^2$.

The matrix representations in the z-basis for the components of electron spin operators are given by:

$$S_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}; \quad S_y = \frac{\hbar}{2}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}; \quad S_z = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

2. The average electrostatic field in the earth's atmosphere in fair weather is approximately given by:

$$\vec{E} = E_0\left(Ae^{-\alpha z} + Be^{-\beta z}\right)\hat{z}, (1$$

where A, B, α, β are positive constants and z is the height above the (locally flat) earth surface.

   (a) (5 points) Find the average charge density in the atmosphere as a function of height.

   (b) (5 points) Find the electric potential as a function of height above the earth.

3. The following questions refer to stars in the table below.

Note: there may be many answers

Name	Mass	Luminosity	Lifetime	Temperature	Radius
β Cyg.	$1.3(M_\odot)$	$3.5(L_\odot)$			
α Cen.	$1.0(M_\odot)$				$1(R_\odot)$
η Car.	$60.0(M_\odot)$	$10^6(L_\odot)$	8.0×10^5(years)		
ε Eri.	$6.0(M_\odot)$	$10^3(L_\odot)$		20,000(K)	
δ Scu.	$2.0(M_\odot)$		5.0×10^8(years)		$2(R_\odot)$
γ Del.	$0.7(M_\odot)$		4.5×10^{10}(years)	5000(K)	

   (a) (4 points) Which of these stars will produce a planetary nebula.

   (b) (4 points) Elements heavier than *Carbon* will be produced in which stars.