PHYS 20323/60323: Fall 2023 - LaTeX Example

1. The following questions refer to stars in the Table below.
Note: There may be multiple answers.

Name	Mass	Luminosity	Lifetime	Temperature	Radius
ηCar.	60. M$\odot$	$10^6 L\odot$	8.0 x $10^5 years$		
ϵEri.	6.0 M$\odot$	$10^3 L\odot$		20,000K	
δScu.	2.0 M$\odot$		5.0 x $10^8 years$		2R$\odot$
βCyg.	1.3 M$\odot$	3.5 L$\odot$			
αCen.	1.0 M$\odot$				1R$\odot$
γDel.	0.7 M$\odot$		4.5 x $10^{10} years$	5000K	

(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.

2. An electron is found to be in the spin state (in the z-basis): $X = A\binom{3i}{4}$

(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 $S_x, S_y, S_z and \overrightarrow{S}^2$

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

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

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

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

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 height above the earth.