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
η Car.	60. $M_\odot$	$10^6 L_\odot$	$8.5 \times 10^5 years$		
ϵ Eri.	6.0 $M_\odot$	$10^3 L_\odot$		20,000 K	
δ Scu.	2.0 $M_\odot$		$5.0 \times 10^8 years$		2 $R_\odot$
β Cyg.	1.3 $M_\odot$	3.5 $L_\odot$			
α Cen.	1.0 $M_\odot$				1 $R_\odot$
γ Del.	0.7 $M_\odot$		$4.5 \times 10^{10} years$	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.

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

(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:

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

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

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

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.