

# 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
$\eta$ Car.	$60. M_{\odot}$	$10^6 L_{\odot}$	$8.0 \times 10^5$ years		
$\epsilon$ Eri.	$6.0 M_{\odot}$	$10^3 L_{\odot}$		20,000 K	
$\delta$ Scu.	$2.0 M_{\odot}$		$5.0 \times 10^8$ years		$2 R_{\odot}$
$\beta$ Cyg.	$1.3 M_{\odot}$	$3.5 L_{\odot}$			
$\alpha$ Cen.	$1.0 M_{\odot}$				$1 R_{\odot}$
$\gamma$ 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): $\chi = A \begin{pmatrix} 3i \\ 4 \end{pmatrix}$

(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:

$$\mathbf{S}_x = \frac{\hbar}{2} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}; \quad \mathbf{S}_y = \frac{\hbar}{2} \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}; \quad \mathbf{S}_z = \frac{\hbar}{2} \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

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

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

where  $A, B, \alpha, \beta$  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.