

PHYS 20323/60323: Fall 2025 - LaTeX Example

1. At time $t = 0$ a particle is represented by the wave function

$$\Psi(x) = \begin{cases} A \frac{x}{a}, & 0 \leq x \leq a \\ A \frac{(b-x)}{(b-a)}, & a \leq x \leq b \\ 0, & otherwise \end{cases} \quad (1)$$

where A , a , and b are constants.

- (a) (3.3 points) Normalize Ψ (i.e., Find A in terms of a and b).
- (b) (3.3 points) Where is the particle likely to be found at $t = 0$?
- (c) (3.4 points) What is the expectation value of x ?

2. **The following questions refer to stars in the table below**

Note: there may be multiple answers.

Name	Mass	Luminosity	Lifetime	temperature	Radius	Variable?
δ Scu.	$2.0 M_{\odot}$		5.0×10^8 years		$2.0 R_{\odot}$	Y
γ Del.	$0.7 M_{\odot}$		4.5×10^{10} years	5000 K		N
β Cyg.	$1.3 M_{\odot}$	$3.5 L_{\odot}$				Y
η Car.	$60. M_{\odot}$	$10^6 L_{\odot}$	8.0×10^5 years			Y
ϵ Eri.	$6.0 M_{\odot}$	$10^3 L_{\odot}$		20,000 K		N
α Cen.	$1.0 M_{\odot}$			6000 K	$1.0 R_{\odot}$	N

- (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.

3. An electron is found 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 for the electron spin operators are given by:

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