Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part C, August 19, 2016, 09:00–12:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.

   (a) All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.

   (b) For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.

   (c) Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.

   (d) All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.

   (e) Each problem is worth 10 points.

   (f) Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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C1. **(Konigsberg)** An electron is in the spin state $\chi = A\binom{3i}{4}$.

(a) [**2.5 points**] Find the normalization contant "A".

(b) [**2.5 points**] Calculate the expectation values of S_x, S_y and S_z.

(c) [**2.5 points**] Find the "uncertainties" $\delta(S_x), \delta(S_y), \delta(S_z)$.

(d) [**2.5 points**] Check if the uncertainty principle is satisfied for all permutations of x, y, z: $\delta(S_x)\delta(S_y) \geq \frac{\hbar}{2}|\langle S_z \rangle|$ for the value of the results obtained in (b) and (c).

Hint: you may find the Pauli spin matrices useful.

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \quad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

and remember that $S = \left(\frac{\hbar}{2}\right)\sigma$.

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

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C2. **(Hebard)** The Gaussian probability distribution for a continuous distribution of observables y has the form

$$p(y) = \frac{1}{\sqrt{2\pi\sigma_y^2}} \exp\left[-\frac{(y-\mu_y)^2}{2\sigma_y^2}\right]$$

where μ_y and σ_y are respectively the true mean and standard deviation of the range of possible values provides the probability for an outcome in that range.

(a) [**points**] For the continuous Gaussian probability distribution iwth the range of y including all possible values (*i.e.*, $-\infty \leq y \leq \infty$) the probability of an outcome is 100%. This imposes a normalization condition $\int_{-\infty}^{\infty} p(y)dy = 1$. Show that this normalization condition is indeed satisfied for the Gaussian distribution. The well-known integration $\int_{-\infty}^{\infty} \exp(-z^2/2)dz = \sqrt{2\pi}$ may be helpful.

(b) [**points**] Calculate the first moment $< y >$ or mean of the distribution *i.e.*, $< y >= \int_{-\infty}^{\infty} yp(y)dy$. Show all steps in your integrations.

(c) [**points**] Calculate the second moment or variance of the distribution, *i.e.*,

$$\sigma_y^2 = \langle (y-\mu_y)^2 \rangle =< y^2 > -\mu_y^2 = \frac{1}{\sqrt{2\pi\sigma_y^2}} \int_{-\infty}^{\infty} (y-\mu_y)^2 \exp\left[-\frac{(y-\mu_y)^2}{2\sigma_y^2}\right] dy.$$

You will need to do an integration by parts. Again show all steps in your integrations.

(d) [**points**] For realistic data sets, the input data comprise a finite data set $y_i, 1, 2, ...N$ where the same probability function describes each y_i. Show that the sample mean defined as $\bar{y} = \frac{1}{N}\sum_{i=1}^{N} y_i$, when averaged, *i.e.*, $< \bar{y} >= \left\langle \frac{1}{N}\sum_{i=1}^{N} y_i \right\rangle$, is equal to the true mean.

(e) [**points**] In like manner show that $\sigma_{\bar{y}}^2 =< (\bar{y}-\mu_y)^2 >=< \bar{y}^2 > -\mu_y^2 = \sigma_y^2/N$. Hint: express $\bar{y}^2 = \left(\frac{1}{N}\sum_{i=1}^{N} y_i\right)\left(\frac{1}{N}\sum_{k=1}^{N} y_k\right)$ and distinguish terms with equal/unequal dummy indices. This last expression, $\sigma_{\bar{y}}^2 = \sigma_y^2/N$ for the standard deviation of the mean shows the advantage of taking a large number of data points to get high precision.

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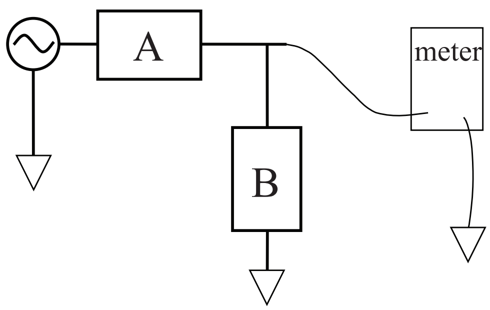
C3. **(Rinzler)** You are given two nondescript (unknown) passive electrical components that each have two terminals (they could both be the same type of component or not) and a 1.00 kΩ resistor R. You have at your disposal a function generator that outputs 1 V RMS at frequencies from 1 Hz to 1 MHz. You are also given a voltmeter that measures only AC RMS voltage. Your challenge is to determine what the components are. Being clever you arrange them in the voltage divider configuration shown below and make AC voltage measurements at 1 Hz and 1 MHz. (A, B) is the configuration shown, (B, A) swaps the components. The values obtained, to two decimal place accuracy are shown in the Table.



Components	V@1Hz	V@1MHz
(A,B)	0.00	1.00
(B,A)	1.00	0.00
(B,R)	0.09	0.09
(R,B)	0.91	0.91
(A,R)	0.00	1.00
(R,A)	1.00	0.00

(a) [**6 points**] Based on these measurements the components are _____ . Only identification based on well justified rationale will get full credit. Give quantitative results wherever possible.

(b) [**4 points**] Further measurements identify the corner frequency (the frequency at which the voltage drops to $\frac{1}{\sqrt{2}}$ of the input voltage) of the (A,B) circuit shown to be 1.59 kHz. That means the value and units for component A must be _____ ?