注意：考試開始鈴響前，不得翻閱試題，
並不得書寫、畫記、作答。

國立清華大學 111 學年度碩士班考試入學試題

系所班組別：生命科學院
丙組(計算生物與人工智慧組)

科目代碼：0602

考試科目：近代物理

－作答注意事項－

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「┏ 由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 111 學年度碩士班考試入學試題

系所班組別：生命科學院丙組

考試科目（代碼）：近代物理(0602)

　*請在【答案卷】作答

1. A spaceship moves at a speed of 0.8c. If its length is L as measured by an observer on the spacecraft, what is the length measured by a ground observer? (15 points)

2. James Webb Space Telescope (JWST) is a space telescope recently launched to succeed the Hubble Space Telescope. Unlike Hubble, which mainly observes visible light, JWST targets a lower frequency range, or infrared, in order to observe high-redshift objects. Please explain **(A)** what a redshift is and its causes (10 points), and **(B)** why observing infrared signals allows JWST to see much older and farther objects than Hubble (10 points)?

3. Schrödinger's equation can be considered as the modern representation of energy conservation in classical physics, which states $E = \frac{p^2}{2m} + V(x)$. The difference is that in Schrödinger's equation the observables E, p and $V(x)$ are replaced by operators which act on the wavefunction $\Psi(x,t)$. Please write down the operators corresponding to E, p and $V(x)$. (20 points)

4. Given the time independent Schrödinger's equation in a one-dimensional infinite potential well, $-\frac{\hbar^2}{2m}\frac{d^2}{dx^2}\psi(x) = E\psi(x)$, **(A)** By assuming $\psi(x) = A\sin kx + B\cos kx$, please show that the energy of a particle in the well is given by $E = \frac{\hbar^2 k^2}{2m}$. (10 points) **(B)** Next, by assuming the width of the well is L and applying proper boundary conditions, show that the solution of the wavefunction is $\psi(x) = A\sin\left(\frac{n\pi x}{L}\right)$, and $k = \frac{n\pi}{L}$. (10 points) **(C)** Finally, by using the normalization condition, show that the constant A is $\sqrt{\frac{2}{L}}$. (10 points)

5. Quantum mechanics has a wide application in biology. Specifically, quantum mechanics is useful in the making of different types of high-resolution microscopy or observation tools, and in explaining various biophysics or biochemistry phenomena. Please name at least one such application and explain how it works? (15 points)