Midterm Exam – Modern Physics

有帶學生證者，將學生證(或身份證/健保卡)置於方便拿取處以便抽驗身份。未帶學生證且被抽驗到者，請配合脫口罩拍攝面部照片，下週補驗。
考試時間: Taipei time 9:10 am–12:00 pm。作答完交卷(請一同繳回試題紙)後即可離場。
請將手機關機。除試題與試卷紙，不可翻開其它印刷品或筆記。考試期間，非修課學生務必離開試場，否則通報校警處理。

考試期間不可將試題與試卷紙攜離試場。考試時間無論在教室內、外交談或使用手機、平板電腦、筆記型電腦、或任何其它有通訊功能之電子及非電子產品(如紙條與其它形式之小抄)皆無視實際溝通內容直接以作弊論。未在考試時間結束前交試卷、或抽驗身份不符者亦以作弊論。為了公平以裨維護用功之實質效益，若發現某特定應考者有任何常識上認為(或監考老師及助教主觀判定)為作弊之行為，則將該應考者驅離試場、考試成績以-5分計、該(作弊)考生學期總成績直接採計作業與期中期末之總和，不參與調分(即作弊劣於完全不會寫)，另依學校規定作其餘處份。避免有嫌疑之動作或行為(如四處探頭)，以免被監考老師或助教誤判影響分數。

滿分為25 points。作答時請標明題號。為了學弟妹好，教他們怎麼念普物可以，但請不要外流考題。不然以後就很難在考題不重複的情形下再出成那麼簡單。

1. Special relativity (10 points)

(1 point) 1.1 What is inertial frame?

(1 point) 1.2 An inertial frame K′ is moving with a velocity $\vec{u}$ with respect to another inertial frame K. Write down how to transform the spatial and time coordinates from K to K′ frame according to Galilean transformation.

(2 points) 1.3 What are the two postulates of the theory of Special Relativity? Write down both of them (you can know one of them by the name of the theory, of course).

(4 points) 1.4 Similar to Problem 1.2, write down the coordinate transform according to Lorentz transformation and explain how it is approximated by the Galilean transformation in the low-velocity limit.

(2 points) In the world with only 1 spatial dimension, two cruisers fly toward a space station. Cruiser B is located in between Cruiser A and the space station. Relative to the station, cruiser A has speed 0.8 c. Relative to the station, what speed is required of cruiser B such that its pilot sees A and the station approach B at the same speed (write down the explicit derivation)?

2. Quantum physics (15 points)

(1 point) Considering that light at wavelength λ can be described with photons. What is the energy of a photon?

(1 point) What is the de Broglie wavelength of a particle?

(1 point) In quantum physics, we look at the evolution of the wave function $\Psi(\vec{x}, t)$. What is the physical meaning of wave function $\Psi(\vec{x}, t)$?

(2 points) Write down the equation $\Psi(\vec{x}, t)$ needs to satisfy, the Schrödinger equation.

(2 points) Derive the general solution of the Schrödinger equation for a free electron and describe how to obtain the energy and momentum of that electron from 巛 solution you wrote. Explain the relation between expression of the momentum here and the de Broglie wavelength.

(3 points) When you solve a potential well/barrier problem, besides the Schrödinger equation, there are three additional constraints on $\psi(\vec{x})$ that you often impose. What are they?

(3 points) Derive and make a general expression for the energy levels of an 1D infinite potential well that has width L.

(2 points) Describe what is Pauli exclusion principle and what is its relation with the periodic table of the elements.