國立中山大學 106 學年度碩士暨碩士專班招生考試試題

科目名稱：普通物理【物理系碩士班選考】　　題號：423002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

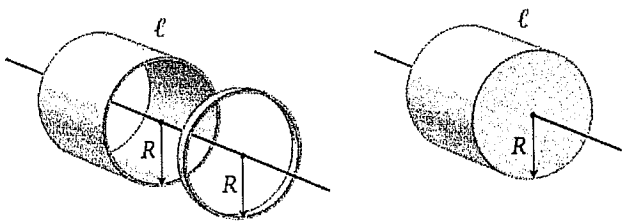
Useful physical constant: permittivity constant (ε_0: 8.85×10^{-12} $C^2/N{\cdot}m^2$); electron charge (e: 1.6×10^{-19} C)

1 [15%]. On an icy day, a driver swerves into the opposite lane and gets into a head-on collision with another car whose inertia is twice that of his. Both cars have the same speed when they hit and lock together. What fraction of their original speed do they have when moving together?

2 [20%]. Please calculate the rotational inertia for the following uniform objects of inertia M about axes through their center of mass (as shown in the figure on the right)

(a) **[10%]** thin-walled cylinder

(b) **[10%]** solid cylinder.

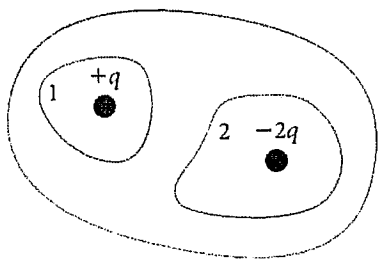


3 [15%]. A cart of mass $m = 0.50$ kg fastened to a spring of spring constant $k = 14$ N/m is pulled 30 mm away from its equilibrium position and then released with zero initial velocity. What are the cart's position and the x component of velocity 2.0 s after being released?

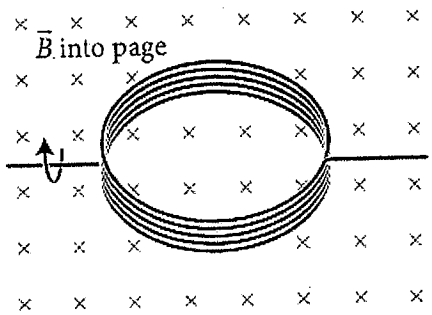
4 [15%]. The two-cavity metal object in the right figure on the right is electrically neutral, but each cavity contains a charged particle as shown. What are

(a) the charge on the surface of each cavity and

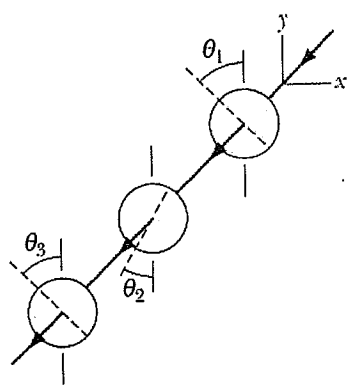
(b) the charge on the outer surface of the object?



5[20%]. A circular coil of radius $R = 50$ mm rotates about an axis that is perpendicular to a uniform magnetic field of magnitude $B = 0.50$ T. If the coil completes 60 rotations each second, how many windings must the coil have in order to power an appliance that requires an emf that varies as $E_{ind}(t) = V_{max} \sin(\nu t)$, where $V_{max} = 310$ V?



6 [15%]. An unpolarized light is sent into a system of three polarizing sheets whose polarizing directions make angles of $\theta_1 = \theta_2 = \theta_3 = 45°$ with the direction of the y axis, as indicated in the right figure. Please evaluate what percentage of the initial intensity is transmitted by the system?



國立中山大學 106 學年度碩士暨碩士專班招生考試試題

科目名稱：近代物理【物理系碩士班】　　題號：423001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

單選題［共十題］

＊1~5 題每題 12 分，6~10 題每題 8 分，答錯不倒扣。

1. [12%] The Lorentz transformation between two spacetime points (x,y,z,t) in reference frame S and (x',y',z',t') in reference frame S' is given by $x'=\gamma(x-vt)$, $t'=\gamma(t-\frac{vx}{c^2})$, where S' is moving with uniform velocity v relative to S, c is speed of light, and γ is the Lorentz factor. Which one is the correct Lorentz factor:

   (a) $\sqrt{1-\beta^2}$

   (b) $\frac{1}{\sqrt{1-\beta^2}}$

   (c) $\frac{1}{\sqrt{1-\beta}}$

   (d) $\sqrt{1-\beta}$

   (e) $\sqrt{1+\beta^2}$, where $\beta=v/c$.

2. [12%] De Broglie stated mathematically the equation for the frequency f and wavelength of electron wave λ. Which one is the equation that are referred to as the de Broglie relations:

   (a) $f=\frac{E}{h},\lambda=\frac{h}{\sqrt{p}}$

   (b) $f=\frac{E}{h},\lambda=\frac{h}{p}$

   (c) $f=\frac{h}{E},\lambda=\frac{h}{p}$

   (d) $f=\frac{E}{h},\lambda=\sqrt{\frac{h}{p}}$

   (e) $f=\sqrt{\frac{E}{h}},\lambda=\frac{h}{p}$, where E is the total energy, h is the Planck's constant, and p is the momentum.

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3. [12%] The normalized wave function of a particle in one-dimensional infinite square well with width L is given by $\psi_n(x) = A\sin\frac{n\pi x}{L}$, where $n = 1,2,3,\cdots$. Which one is the normalized factor A.

(a) $\frac{2}{L}$

(b) $\frac{1}{L}$

(c) $\sqrt{\frac{1}{L}}$

(d) $\sqrt{\frac{2}{L}}$

(e) $\sqrt{\frac{1}{2L}}$

4. [12%] The ground state wave function for hydrogen atom is

(a) $N\exp(-r/a_0^2)$

(b) $N\exp(-r^2/a_0^2)\sin\theta\exp(i\phi)$

(c) $Nr^2\exp(-r^2/a_0^2)$

(d) $N\exp(-r^2/a_0^2)$

(e) $N\exp(-r/a_0)$, where N is the normalized factor and a_0 is the Bohr radius.

5. [12%] The Fermi-Dirac distribution at temperature T is given by

(a) $\frac{1}{e^{\alpha}e^{-E/kT}-1}$

(b) $\frac{1}{e^{\alpha}e^{E/kT}-1}$

(c) $\frac{1}{e^{\alpha}e^{E/kT}+1}$

(d) $\frac{1}{e^{\alpha}e^{-E/kT}+1}$

(c) $\frac{1}{e^{-\alpha}e^{-E/kT}+1}$

,where E is the particle energy, k is the Boltzmann constant, $\alpha = -\frac{E_F}{kT}$ and E_F is called Fermi energy.

6. [8%] The ground state of electron configuration is denoted as term ${}^{2s+1}L_J$, where s, L and J means spin, orbital and total angular momentum, respectively. Consider the subshell p state electron, which one is the possible term:
   (a) ${}^6S_{5/2}$
   (b) ${}^5D_0$
   (c) ${}^3P_2$
   (d) ${}^3P_4$
   (e) ${}^5D_{5/2}$

7. [8%] The total energy of a Fermi gas is given by $E_{total} = \int_0^{E_F} ED(E)dE$, where $D(E)$ is the density of state and E_F is the Fermi energy. Consider a Fermi gas in a three-dimensional box, the density of state is proportional to E^n, find the number of n.
   (a) 1/2
   (b) 3/2
   (c) 5/2
   (d) 2
   (e) 1/3

8. [8%] Follow Problem No. 7. The total energy of a Fermi gas in the ground state is given by $E_{total} = CN_sE_F$, where N_s is the number of possible quantum state states. Find the coefficient C.
   (a) 1/4
   (b) 5/8
   (c) 3/5
   (d) 4/7
   (e) 3/2

9. [8%] If a magnetic moment is placed in an inhomogeneous external magnetic field that is symmetric in the x and y component, the magnetic moment will feel an external force that depends on the z component of magnetic field. In 1922, Stern and Gerlach had made the first direct observation of electron spin and space quantization by showing that the silver atoms strike in upper and lower lines (two lines), where the ground state of the silver atom is given by the term ${}^2S_{1/2}$. Consider oxygen atoms with ground state ${}^3P_2$. How many lines will appear in the Stern-Gerlach experiment?
   (a) 2
   (b) 3
   (c) 4
   (d) 5
   (e) 7

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10. [8%] Consider a region in which the potential energy is a step function: $V(x<0)=0, V(x>0)=V_0$. Suppose that $k_1=\sqrt{2mE}/\hbar$ and $k_2=\sqrt{2m(E-V_0)}/\hbar$ are wave vectors in regions $x<0$ and $x>0$, respectively. The total energy $E>V_0$. Define the coefficient of transmission as $T=\frac{k_2|C|^2}{k_1|A|^2}$, where A and C are amplitudes of the transmission wave at regions $x<0$ and $x>0$. Find the coefficient of transmission T.

(a) $T=\frac{k_1k_2}{(k_1+k_2)^{1/2}}$

(b) $T=\frac{2k_1k_2}{(k_1+k_2)^{1/2}}$

(c) $T=\frac{2k_1k_2}{(k_1+k_2)^{2}}$

(d) $T=\frac{4k_1k_2}{(k_1+k_2)^{1/2}}$

(e) $T=\frac{4k_1k_2}{(k_1+k_2)^{2}}$