國立中山大學 103 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】　　題號：423001

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

【$\mu_0 = 4\pi\times10^{-7}\ C^2/N\cdot m^2$，$k_e = \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ N\cdot m^2/C^2$，$m_e = 9.1\times10^{-31}\ kg$，$m_p = 1.67\times10^{-27}\ kg$】

1. **[15%]** A block of mass $m = 0.5\ kg$ is held against a massless spring which is compressed by $A = 15\ cm$ from its equilibrium position O to point P as shown in Fig. 1. Take the friction coefficient to be $\mu_k = 0.4$ and the spring constant to be $k = 120\ N/m$. When the system is released from point P, find:
   (a) (5%) The work done by the spring on the block until the block reaches the point O.
   (b) (5%) The speed at which the block reaches the point O.
   (c) (5%) How far the block travels from point O before coming to stop?

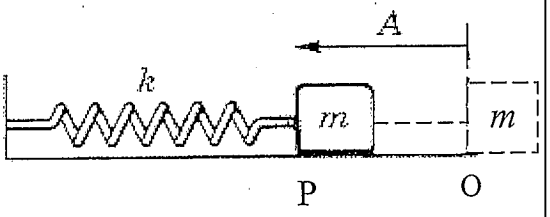

Fig. 1

2. **[15%]** A massless rope is wrapped around a uniform cylinder that has radius R and mass M, as shown in Fig. 2. Initially, the unwrapped portion of the rope is vertical and the cylinder is horizontal. Calculate the linear acceleration of the cylinder.
   (The rotational inertia of a cylinder $I_C = \frac{1}{2}MR^2$)

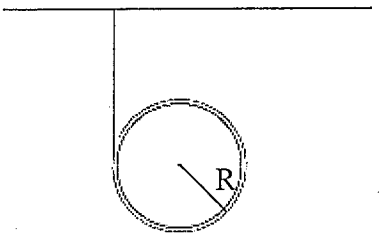

Fig. 2

3. **[20%]** Figure 3 shows a cycle undergone by 1.00 mole of an ideal monatomic gas. The temperatures are $T_1 = 200$ K, $T_2 = 400$ K, and $T_3 = 300$ K. The initial pressure at point 1 is 1.00 atm ($= 1.013\times10^5$ Pa). The gas constant $R = 8.31$ J/mol · K. Find:
   (a)(9%) The heat Q absorbed or rejected ("sign" is relevant!) for the 1 → 2, 2 → 3, and 3 → 1 processes, respectively.
   (b)(6%) According to (a), for the full cycle, what is the net Q?
   (c)(5%) In addition, what is the net work W by the gas for the full cycle?

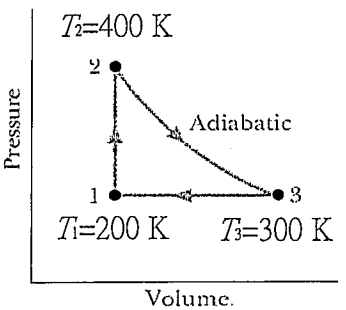

Fig. 3

4. **[10%]** Switch S in Fig. 4 is closed at time $t = 0$, to begin charging an initially uncharged capacitor of capacitance $C = 20.0\ \mu F$ through a resistor of resistance $R = 50.0\ \Omega$ and a battery with emf ε.
   (a) (5%) What are the potential differences across the resistor and the capacitor at time $t = 10^{-3}$ sec, respectively?
   (b) (5%) At what time is the potential across the capacitor just half of that across the resistor?

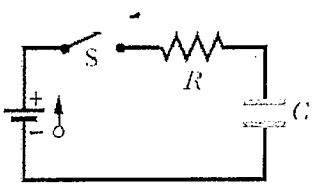

Fig. 4

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5. **[10%]** Figure 5 shows, in cross section, a cylindrical capacitor of length L formed by two coaxial cylinders of radii a and b. We assume that $L >> b$ so that we can neglect the fringing of the electric field that occurs at the ends of the cylinders. If the inner cylinder has a charge $+q$,

(a) (4%) derive that the capacitance of this cylindrical capacitor is $C = 2\pi\varepsilon_0 \dfrac{L}{\ln(b/a)}$;

(b) (3%) What is the energy density at $r = a$?

(d) (3%) If this capacitor is filled with dielectric materials with the dielectric constant κ, what is the capacitance of this cylindrical capacitor?

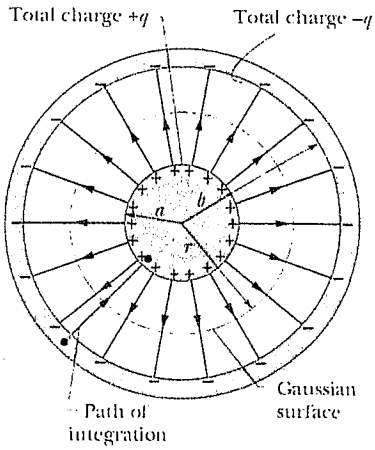

Fig. 5

6. **[20%]**

(a)(8%) Write down Maxwell's Equations of electromagnetism on the assumption that no dielectric or magnetic materials are present and explain the characteristics of theses equations.

(b) In Fig. 6, a parallel-plate capacitor has square plates of edge length L = 1.0 m. A current of 2.0 A charges the capacitor, producing a uniform electric field $\vec{E}$ between the plates, with $\vec{E}$ perpendicular to the plates.

(1)(4%) What is the displacement current i_d through the region between the plates?

(2)(4%) What is dE/dt in this region?

(3)(4%) What is the displacement current encircled by the square dashed path of edge length d = 0.50 m?

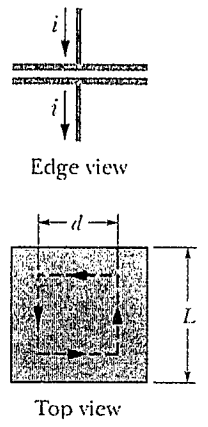

Fig. 6

7. **[10%]** A glass lens is coated on one side with a thin film to reduce reflection from the lens surface. The index of refraction of the glass is 1.60. If the index of refraction of the thin film is 1.38, what is the least coating thickness that eliminates (via interference) the reflections at the middle of the visible spectrum (λ = 550 nm)? Assume that the direction of the light is approximately perpendicular to the lens surface.

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科目名稱：近代物理【物理系碩士班】　　題號：423002

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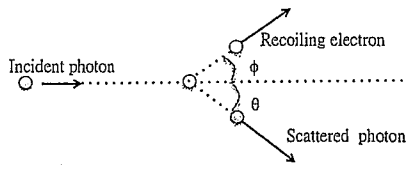
1. (20%) A particle of mass m can move only along the x-axis between two points at $x = 0$ and $x = L$, find the particle's possible wave functions and the associated expectation values $< x^2 >$.
2. (20%) Allen is on a powerless rocket moving with a speed of 0.8c. Bob is on another powerless rocket moving with a speed of 0.6c. These two rockets are on a collision course. The distance between Allen and Bob is initially 2.52×10^{12}m. The speeds and distance are measured by Charles on the Earth. How long will it take before they collide as estimated, respectively, by Allen, Bob, and Charles?
3. (20%) In a particular Compton scattering, as shown to the right, the energy of the incident photon is 1.02 MeV and the scattering is symmetric, *i. e.,* of equal scattering angles $\theta = \phi$. Find (a) (10%) the scattering angle θ, and (b) (10%) the energy of the scattered photon.



4. (20%) A very small ball is held by a man at (0, 0, H), that is, at a height H above the ground. The horizontal position of the ball is measured to an accuracy of $\pm\frac{1}{2}\Delta x_0$. The ball is then let go to vertically hit the ground at (0, 0, 0). Estimate the minimal miss distance on the ground from (0, 0, 0).
5. (20%) (a) (6%) List three different physical phenomena that are difficult to explain with classical physics but are explainable using quantum physics. (b) (14%) Explain (a) with your views about them in detail.