1. Solve the initial value problem:
$y'' + y = 0.001\,x^2$, $y(0) = 0$, $y'(0) = 1.5$ (15 %)

2. Find the value of $\int_C F(r)dr = \int_a^b F(r(t))r'(t)dt$

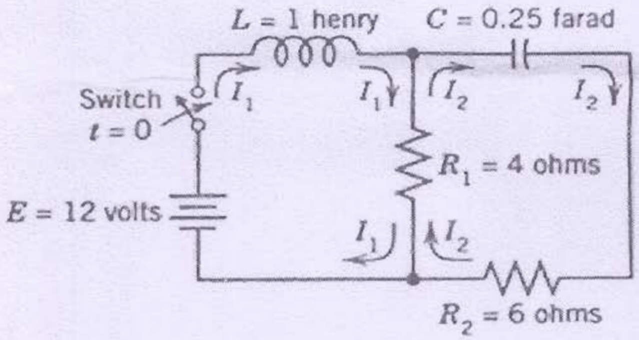
when $F(r) = [z, x, y] = z\,\hat{i} + x\,\hat{j} + y\,\hat{k}$ and C is a helix:

$r(t) = [\cos t, \sin t, 3t] = \cos t\,\hat{i} + \sin t\,\hat{j} + 3t\,\hat{k}$ $(0 \leqq t \leqq 2\pi)$

(20 %)

3. Find the Fourier series of the function:
$f(x) = x + \pi$ if $-\pi < x < \pi$ and $f(x + 2\pi) = f(x)$ (20 %)

4. Find the currents $I_1(t)$ and $I_2(t)$ in the figure below. Assume all currents and charges to be zero at t=0, the instant when the switch is closed. (15 %)



5. Find the temperature $u(x, t)$ in a laterally insulated copper bar 80 cm long if the initial temperature is $100 \sin (\pi x/80)$ °C and the ends are kept at 0 °C. How long will it take for the maximum temperature in the bar to drop to 50 °C? Assume physical data for copper: density 10 g/cm^2, specific heat 0.1 cal/g.°C, and thermal conductivity 1 cal/cm.s.°C. (15 %)

6. Find an upper bond for the absolute value of the integral:
$\int_C z^2 dz$, C the straight-line segment from 0 to $1+i$ (15 %)

1. (10%) Figure 1 shows the basic structure of a step-index optical fiber with the dielectric constants of the core and cladding being ε_1 and ε_2, respectively. Please find out the acceptance angle of the fiber, that is, the maximum value of θ to induce the total internal reflection at the core-cladding interface, and describe why we use optical fiber instead of microwave waveguides or metallic waveguides for light transmission?

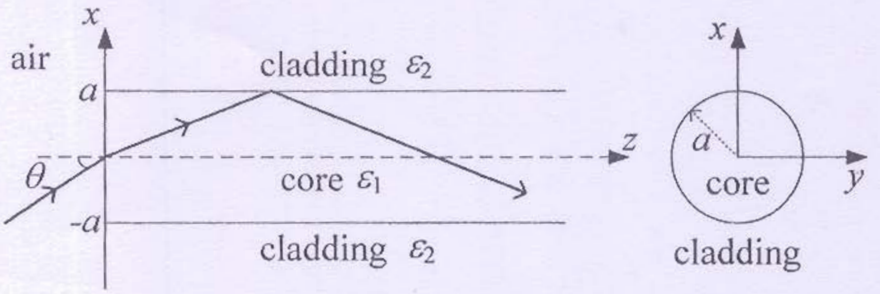


Figure 1.

2. (12%) A point charge Q is placed between two large intersecting conducting planes as shown in Fig. 2. Find out the surface charge density on the horizontal conducting plane.

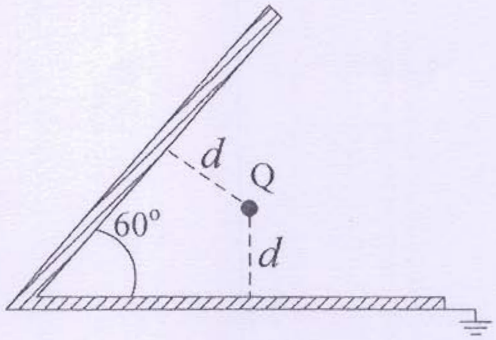


Figure 2.

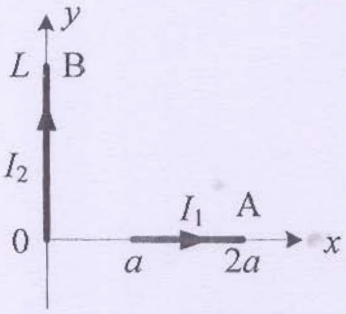


Figure 3.

3. (12%) A straight conducting wire A carrying current I_1 (length = a) is placed near another straight conducting wire B (length = L) carrying current I_2 as shown in Fig. 3. Please find out the magnetic force experienced by the wire A.

4. (12%) Assume an antenna generates the radiation fields (in far region) as $E_\theta = \dfrac{\eta\beta(I_0 dl)\cos\theta}{4\pi R}e^{-j\beta R}$ and $H_\phi = \dfrac{\beta(I_0 dl)\cos\theta}{4\pi R}e^{-j\beta R}$. Please describe the meaning of the **directivity** of an antenna and find out the directivity of this antenna.

5. (12%) A transmission line of characteristic impedance $R_0 = 50$ (Ω) is to be matched to a load impedance $Z_L = 30 + j10$ (Ω) through another transmission line with length L and characteristic impedance R. Please find out the required L and R.

6. (12%) For a sinusoidal time-varying uniform plane wave propagating in free space, the frequency is $f = 2$ GHz and the polarization is right-hand circular. The wave propagates in the $-z$ direction with the initial conditions $E_x(z = 0, t = 0) = \sqrt{3}\,E_0$ and $E_y(z = 0, t = 0) = E_0$. (a) Please express the electromagnetic field, $\mathbf{E}(z, t)$ and $\mathbf{H}(z, t)$, of this wave. (b) Write the Poynting vector of this wave. (c) If this wave is incident from free-space into a dielectric medium, please describe the polarization states of the transmitted and reflected wave.

7. (30%) Consider a dielectric slab waveguide with the indices $n_1 > n_s > n_2$, shown in Fig. 4. For **TE modes:** (a) Please derive the corresponding wave equation in terms of E_y. (b) If E_y can be expressed as $E_y = A\cos(k_x x - \phi)$ in the core region with k_x being the wavenumber along the x-axis in the core, please express E_y in the cladding and substrate regions. (c) Please find out the dispersion equation by fulfilling the continuity condition. (d) Derive the cutoff frequencies for the TE modes. (e) If $n_1 = 1.6$ and $n_2 = n_s = 1.5$, find out the maximum value of a to support single-mode operation for an incident light with free-space wavelength being 1.3 μm.

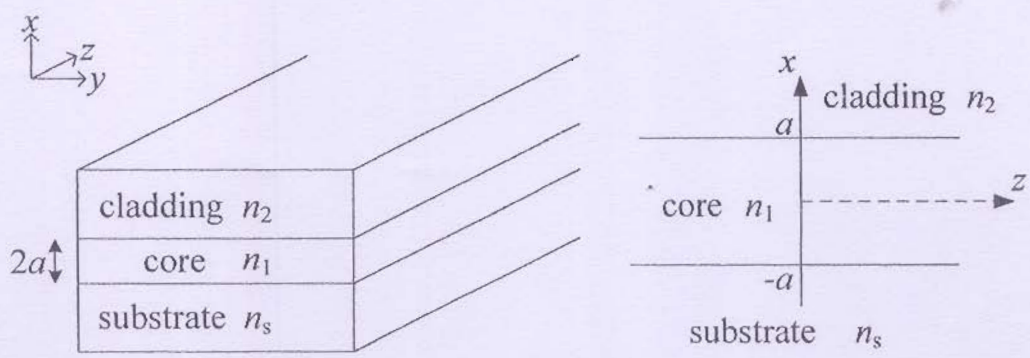


Figure 4.

Answer the following questions:

1. What is the difference between intrinsic and extrinsic semiconductors? (5%)
2. Please draw the electric field intensity and electrostatic potential for electrons in the depletion region of a pn junction. (5%)
3. What is the Early voltage? (5%)
4. What are the typical values of V_{BE} of a BJT at cut-in, active, and saturation? (5%)
5. Please draw the circuit of a simple BJT inverter? (5%)
6. What is the most extensively used analogy integrated circuit? What are the input and output resistance of this integrated circuit? (5%)
7. What are the four topologies of feed-back amplifiers? Which one (or ones) is suitable for applications of circuits with high input impedance? (8%)
8. The circuit shown in Fig. 1 includes two identical NMOS enhancement drivers and one depletion load. What is its function? Please use the truth table to verify your answer. (8%)

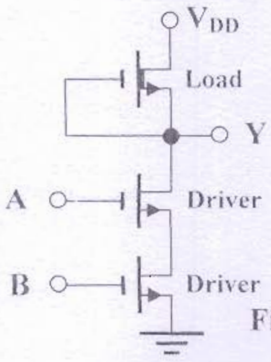


Fig. 1

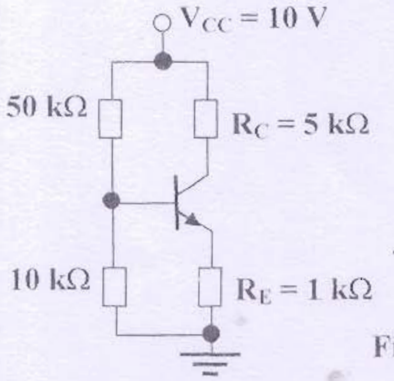


Fig. 2

9. What is the DC equivalent circuit of the circuit shown in Fig. 2? (8%)
10. The circuit shown in Fig. 3 is often referred to as a Darlington pair. Please show that the current gain (I_C/I_{b1}) of the circuit is β^2, where β is the current gain of each transistor. (8%)

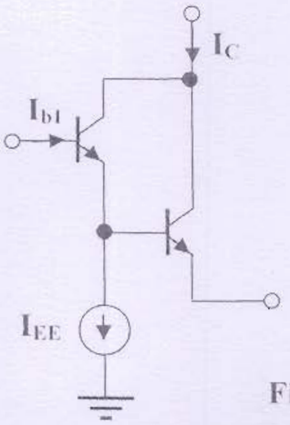


Fig. 3

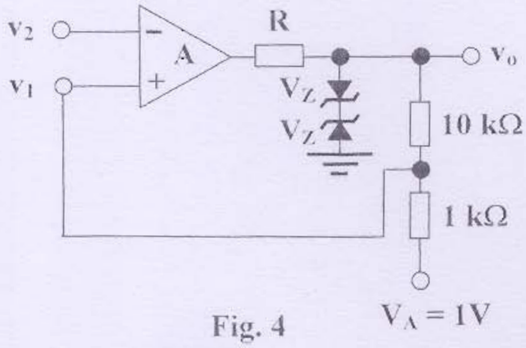


Fig. 4

11. The Schmitt trigger, as shown in Fig. 4, makes the change in output from -7 V to +7 V for a swing in input of about 1 mV. Please find the hysteresis voltage of the circuit. (8%)

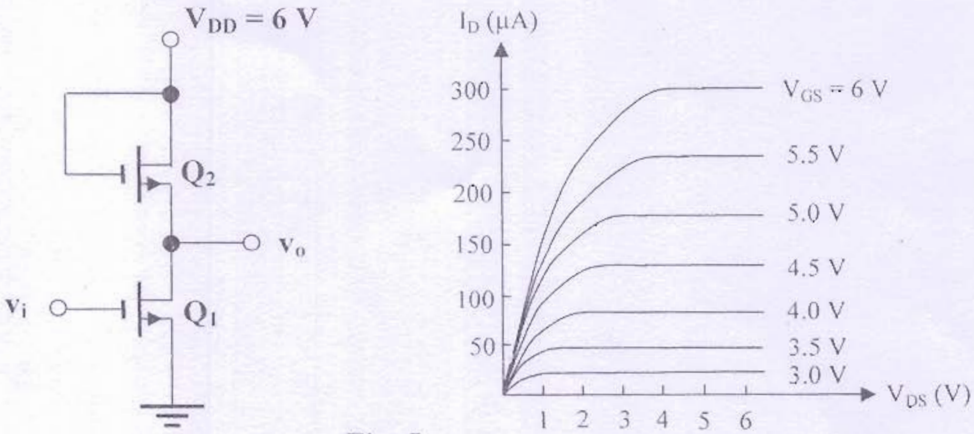


Fig. 5

12. As shown in Fig. 5, the circuit contains two identical transistors with $V_T = 2$ V. Q_1 is the driver, and Q_2 is the load. Please draw the resistance characteristic, load line, and voltage transfer characteristics of the circuit. (15%)

13. The return ratio of a two-pole amplifier is

$$T(s) = \frac{100}{(1 + s/10^6)(1 + s/9 \times 10^6)}$$

Please determine the phase margin. Is this amplifier stable? (15%)

2008 年中山大學光電工程研究所碩士班招生考試
-近代物理

1.名詞解釋(請簡要說明)(每小題五分共 20%)

(a) Stark effect

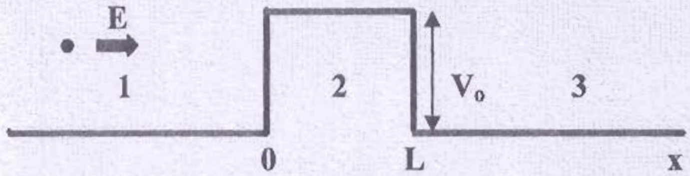
(b) Bohr radius

(c) Selection rule

(d) Uncertainty principle

2.如圖，電子(帶有能量為E)由左往右入射一 retangular barrier(位障高為 V_0)

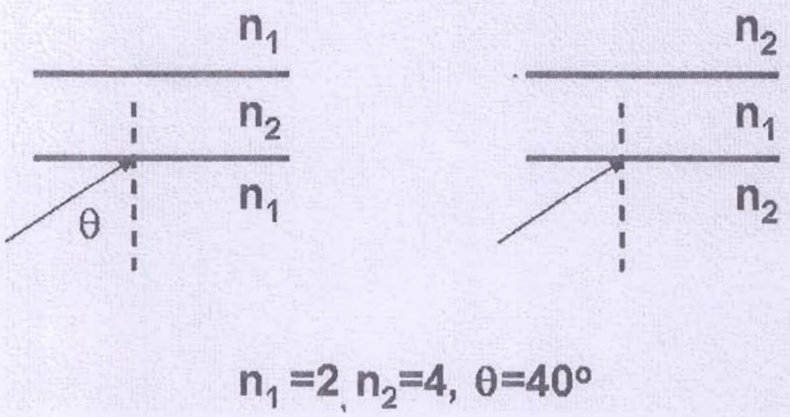
$$V(x)=\begin{cases} 0, & x<0, x>L \\ V_0, & 0<x<L \end{cases}$$



(a)若 $E>V_0$.請寫出所有區域的波函數?(6%)在 x=0 與 x=L 的邊界條件為何?(6%)

(b)寫出穿透 barrier 的效率 tunneling coefficient T 與反射效率 reflection coefficient?(12%)

(c)若對應到電磁波在介質中傳播行為，請說明當電子能量 $E<V_0$ 時的行為是等同於下列左右何種折射率分佈？(6%)



$n_1=2$、$n_2=4$, $\theta=40°$

3. 載子遷移率 mobility 是現今設計電子元件一個重要參數，請利用所學知識說明如何量測得到材料的 mobility(10%)

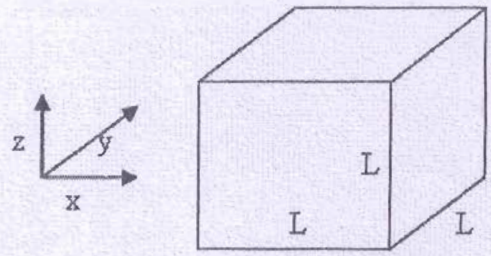
4. 二倍頻產生(Second-Harmonic-Generation, SHG)是非線性光學中一個基本的現像，透過適當的安排(如晶體與偏極方向等)，兩個相同頻率的光子可產生頻率為兩倍於入射光(基頻光)頻率值之光(倍頻光)，但過程中能量與動量守恆依舊成立。

(a) 請問波長 800nm 的近紅外光 IR，其倍頻光之波長為?(10%)

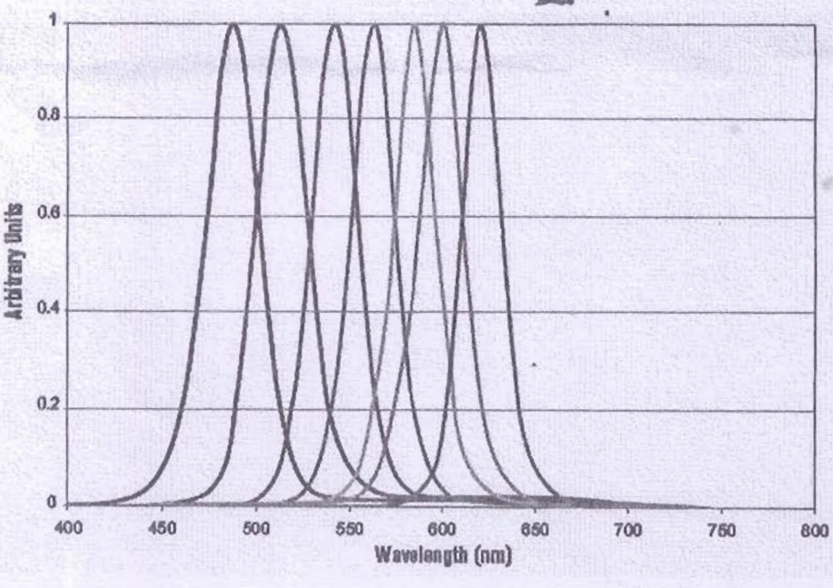
(b) 如果晶體中的折射率對基頻光與倍頻光不同，請問 SHG 會存在嗎?(請說明或證明)(10%)

5. 下圖為一典型不同尺寸大小量子點的發光光譜，由左至右波長漸增之光譜是來自大小由 1.9 到 4.8nm 漸增的 CdSe/Zns Core-shell 的量子點材料，請根據三維無限位能井

$$V(x,y,z)=\begin{cases} 0, & 0<x<L \\ 0, & 0<y<L \\ 0, & 0<z<L \\ \infty, & Others \end{cases}$$



說明何以發光波長與量子點大小有此關係。(20%)



source: Evident Technologies, Inc.