招生學年度	九十九	招生類別	碩士班
系所班別	光電工程學系碩士班		
科目	近代物理		
注意事項	本考科可使用掌上型計算機		

1. (5%) Choose one appropriate answer: the photoelectric effect demonstrates that: (A) light sometimes acts like particles. (B) electrons sometimes act like waves. (C) it is possible to violate the law of conservation of energy. (D) the speed of light is absolute.

2. (20%) A metal surface illuminated by light of wavelength 3.5×10^{-7}m emits electrons whose maximum kinetic energy is 0.60eV. The same surface illuminated by light of wavelength 2.5×10^{-7}m emits electrons whose maximum kinetic energy is 2.02eV. Find (a) Planck's constant in eV and (b) the work function of the metal in eV.

3. (10%) Consider a photon in a perfectly mirrored box of length L. This is a "quantum particle in a box" problem, but our conventional results do not apply because our derivations assumed that the quantum particle was non-relativistic. The main difference between a photon and a non-relativistic particle is the relationship between energy and momentum. Use the proper relationship to determine the possible energies of a photon in a perfectly mirrored box.

4. (10%) The ionization energy of hydrogen atoms (Z = 1) is 13.6 eV. Argue that a transition from any level in the hydrogen atom to the n=3 level will produce a photon whose wavelength is too long to be visible.

5. (20%) An electron is trapped in a one-dimensional potential well with a barrier height of 3eV. Assume that the thickness of the well 1nm. (a) Find the lowest energy state in the potential well. (b) Find the probability of the electron's escape from its lowest energy state in the well.

6. (15%) The bandgap of Ge and Si are 0.7eV and 1.1eV, respectively. By calculating the relative number of atoms that are excited to the upper band, compare and discuss the conductivity of the intrinsic Ge and the intrinsic Si (a) at very low temperature, (b) at room temperature.

7. (20%) (a) The cosmic microwave background radiation has a temperature about 2.7 K. What wavelength λ_{max} (in m) corresponds to the maximum spectral density $u(\lambda,T)$ of the cosmic background radiation? (b) Assume that a human body can be approximated by a "black-body" sphere with a radius of 0.25m at T=310K. Find the total power emitted by the body and the related mass loss in one second.

招生學年度	九十九	招生類別	碩士班
系所班別	光電工程學系碩士班、材料科學與工程學系碩士班		
科目	工程數學		
注意事項	本考科可使用掌上型計算機		

1. (10%) Solve $\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + y = xe^{-x}$

2. (15%) Solve $x\frac{dy}{dx} - (x+1)y - x^2 + x^3 = 0$

3. (15%) Find the eigenvalues and eigenfunctions of the problem

$$\frac{d^2y}{dx^2} + \lambda y = 0, \text{ with } y(0) = y(a) = 0$$

4. (15%) Use the Laplace transform to solve the equation

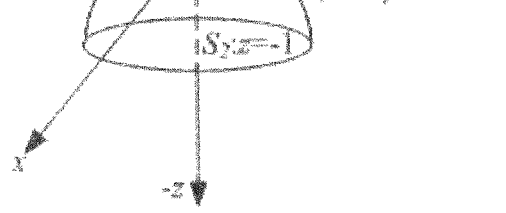
$$y(t) = t - e^t \int_0^t e^{-\tau} y(\tau) d\tau$$

5. (15%) Find the Fourier series of a periodic function

$$f(x) = |\sin x|;\ |x| \le \pi$$

6. (15%) Given a matrix A=$\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix}$, please find A^7.

7. (15%) Given Stoke's theorem as $\iint_S (\vec{\nabla} \times \vec{F}) \cdot \hat{n}\, dA = \oint_c \vec{F} \cdot d\vec{r}$ and Green's theorem as $\iint_R (\frac{\partial Q}{\partial x} - \frac{\partial P}{\partial y})\, dxdy = \oint_c Pdx + Qdy$. Evaluate $\iint_{S_1} (\vec{\nabla} \times \vec{F}) \cdot \hat{n}\, dA$ and $\iint_{S_2} (\vec{\nabla} \times \vec{F}) \cdot \hat{n}\, dA$, where $\vec{F} = x\vec{i} + (z-x)\vec{j} + x\vec{k}$. S_1 and S_2 are shown in the accompanying figure.



招生學年度	九十九	招生類別	碩士班
系所班別	電機工程學系碩士班、光電工程學系碩士班		
科目	電磁學		
注意事項	本考科可使用掌上型計算機		

1. A finite line charge of length L carrying uniform line charge density ρ is coincident with the x-axis.
   (a) (8%) Determine the electric potential V at point P on the plane bisecting the line charge, and the distance from point P to the line charge is h.
   (b) (8%) Determine electric field intensity E at point P on the plane bisecting the line charge, and the distance from point P to the line charge is h.

2. A homogeneous dielectric ($\varepsilon_r = 2.5$) fills region 1 ($x \le 0$), while region 2 ($x \ge 0$) is free space.
   (a) (9%) If $\mathbf{D}_1 = 12\mathbf{a}_x - 10\mathbf{a}_y + 4\mathbf{a}_z$ nC/m^2, find electric flux density $\mathbf{D}_2$ in region 2,
   (b) (9%) If the magnitude of electric field intensity E_2=12V/m in region 2, find the magnitude of electric field intensity E_1 in region 1.

3. Two lossy dielectric media with permittivities and conductivities (ε_1, σ_1) and (ε_2, σ_2) are in contact. An electric field with a magnitude E_1 is incident from medium 1 upon the interface at an angle α_1 measured from the common normal.
   (a) (8%) Find the magnitude and direction of $\mathbf{E}_2$ in medium 2.
   (b) (8%) Find the surface charge density at the interface.

4. A hollow tubular conductor is constructed from a type of brass having a conductivity of 1.2×10^7 S/m. The inner and outer radii are 9 and 10 mm, respectively. Calculate the resistance per meter length at a frequency of :
   (a) (10%) dc;
   (b) (10%) 2 GHz

5. A solenoid is 50-cm long, 2 cm in diameter, and contains 1500 turns. The cylindrical core has a diameter of 2 cm and a relative permeability of 75. This coil is coaxial with a second solenoid, also 50 cm long, but with a 3 cm diameter and 1200 turns. Calculate:
   (a) (5%) self-inductance for the inner solenoid;
   (b) (5%) self-inductance for the outer solenoid;
   (c) (5%) mutual-inductance between the two solenoids.

6. The magnetic field intensity of a linearly polarized uniform plane wave propagating in the + y-direction in seawater [$\varepsilon_r = 40$, $\mu_r = 1$, $\sigma = 8$ S/m] is

   $$\boldsymbol{H} = 2\cos(2\pi \times 10^{10} t - \pi/3)\, a_x \quad \text{(A/m)} \quad \text{at} \quad y = 0.$$

   (a) (5%) Determine the wavelength.
   (b) (5%) Determine the skin depth.
   (c) (5%) Write the expression for $\boldsymbol{E}(y, t)$ for all y and t.

招生學年度	九十九	招生類別	碩士班
系所班別	電機工程學系電子工程碩士班、光電工程學系碩士班		
科目	電子學		
注意事項	本考科可使用掌上型計算機		

1. (20%) Please answer the following questions.
   (a) What are the P-type and N-type semiconductors?
   (b) What are the depletion region and the built-in voltage of a PN junction?
   (c) What are the small signal model and the channel length modulation effect of an NMOS transistor?
   (d) What is the meaning of frequency response for circuits?
   (e) What will be the best choice of an input-stage, an inter-stage, and an output-stage while arranging a three-stage amplifier?
2. (10%) Design a CMOS logic gate circuit that realizes the function $V_{out} = \overline{x_1(x_2 + x_3)}$.
3. (15%) The emitter follower in Fig.1 is used to connect with R_{sig}=10 kΩ to a load R_L= 10 kΩ. The transistor is biased at I=2mA, utilizes a resistance R_B =10 kΩ, and has β=100 and V_T=25mV.
   (a) Find the input resistance (R_{in})
   (b) Find the output impedance (R_{out}) .
   (c) Find the overall gain (A_V= v_o /v_{sig}).

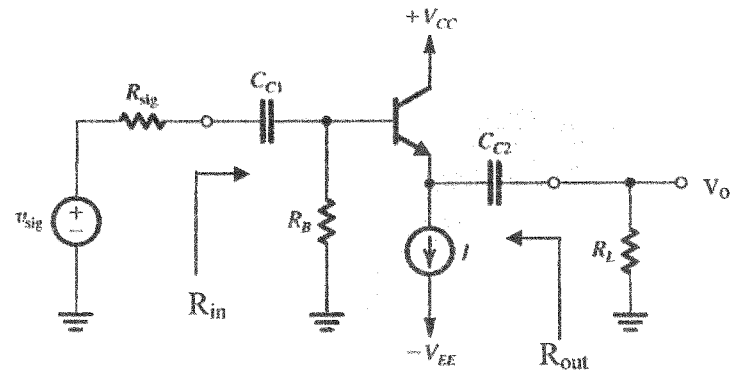


Fig.1

4. (15%) A common-source amplifier in Fig.2 is designed to amplify the input signals with R_{sig}=10kΩ, R_G=40kΩ, R_D=R_L=20kΩ, and C_{C1}= C_{C2}= C_S=1 μF. The NMOS transistor is biased to have g_m=2 mA/V and r_o=100 kΩ, C_{gs}=C_{gd}=1 pF.
   (a) Find the overall gain (Av=V_o/V_{sig}).
   (b) Find the low -3dB frequency (f_L).
   (c) Find the high -3dB frequency (f_H).

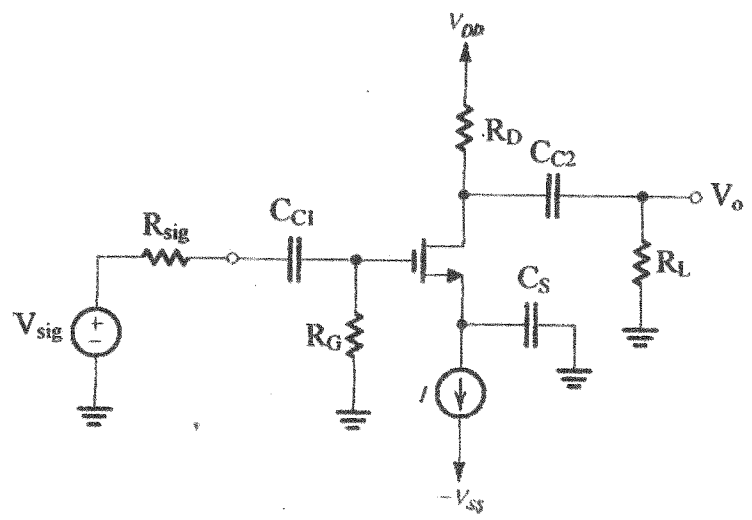


Fig.2

招生學年度	九十九	招生類別	碩士班
系所班別	電機工程學系電子工程碩士班、光電工程學系碩士班		
科目	電子學		
注意事項	本考科可使用掌上型計算機		

5. **(20%)** For the feedback circuit shown in Fig. 3, the op-amp has open-loop gain $u = 10^4\ V/V$, $R_{id} = 100\ k\Omega$, and $r_o = 1\ k\Omega$. Please determine,

(a) The feedback type, (b) The feedback factor, β, (c) The input resistance, R_{in}, (d) The output resistance, R_{out}, and (e) The voltage gain, V_o/V_s.

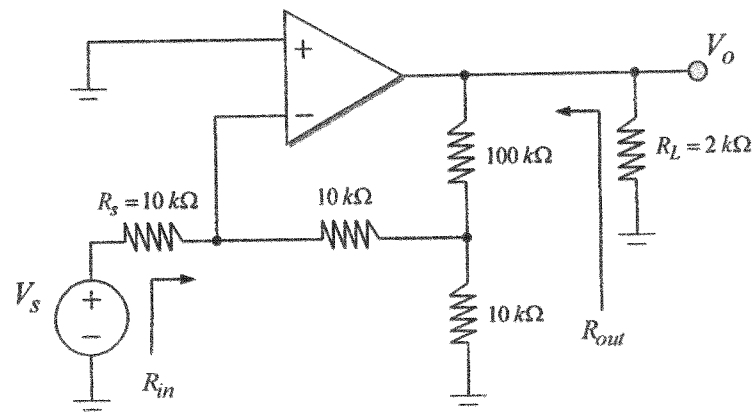


Fig. 3

6. **(20%)** For the oscillator circuit shown in Fig. 4, please find,

(a) The oscillator frequency, and (b) The oscillator condition.

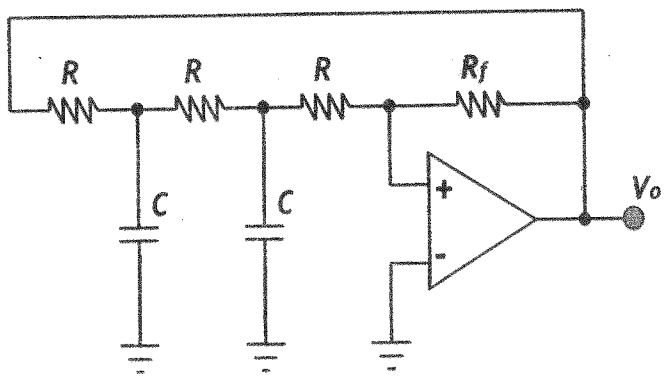


Fig. 4