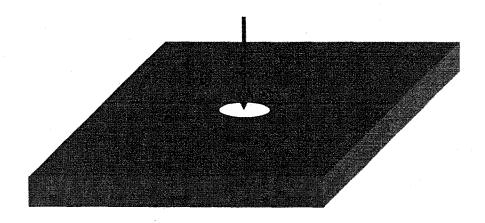
Shanhui Fan

In this exam, the metal is all assumed to be perfect metal. (i.e. perfect electrical conductor).

- (a) What are the boundary conditions for the electric fields at the metal-air interfaces?
- (b) What are the boundary conditions for the magnetic fields at the metal-air interfaces? Why?
- (c) Consider an infinitely long cylindrical air hole inside a metal, sketch qualitatively the $\omega \sim \beta$ diagram for the lowest order propagating modes inside the hole, where ω is the angular frequency for the waves and β is the propagation constant. (i.e. the field varies along the z-direction, defined as the axis of the cylinder, as $e^{-i\beta z}$.)
- (d) Sketch the electric field vector distribution of the lowest order propagating inside the hole.
- (e) Consider the following experiment, where a plane wave is incident upon a metal film with a hole introduced in it. Could you sketch the amount of transmitted power as the wavelength is varied from $\lambda >> a$ to $\lambda \sim a$, where a is the radius of the hole?



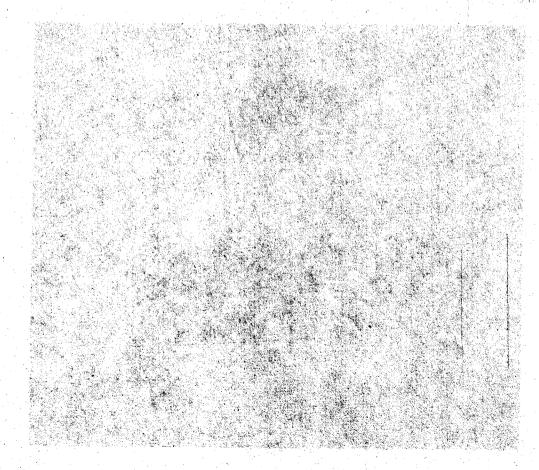
ershame Research MAN

Scoring: (a) 1; (b) 2; (c) 2; (d) 2; (e) 2; (f) 3. In (c), a rough estimate of the cut-off 1 point

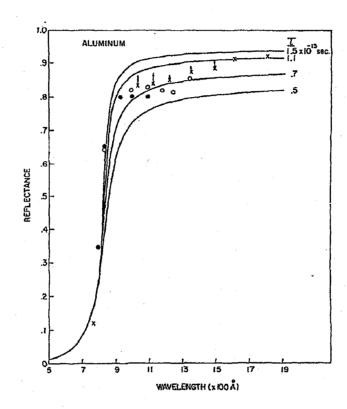
In (f), plot of the cut off 2 point, Fabry Perot oscillation 1 point.

THE PROPERTY.

15 C. Lindolf Lindolf in recognition when the property for the appropriate from the first the court of being bid P. में भी में के किया है। जिस्से के में के लेकिन के बेर्क के बेर के किया है। जिस्से के बार के किया के किया है। जिस principal in the first and even in the control to be a self at the control of the control of the control of the O' to I inches, so with post out parcel with the title with the terms larger for the bracker flowing างสาวอุกมองที่สุดการสล้า (การกรุงยาวที่) สามาชาวัน<mark>ยองค่าสอง</mark> และโดยอุการกายคลักไทย การต่อง (การต่อง การสีทธิ์) nacyalitaki, akiptoli ilitari padenandi etapandi eta bankon basar penalah bibli liberakan belili i derjakiban 三十二年,在1986年,1866年,1986年,1986年,1987年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1988年,1 ti om i damelo koli logista kriti til je opjagasti, ortito dagasti, politikali kritikalianska ja til tolo i og daga The statement of the complete the first of the second of the statement of the contract of the the discount for the relative content of the marking wind though it was in the relative content of the content of gard ered, and rather effections on a section has a language of finish on authorized field the The same of the second and the second of the second because in the second of the secon के जिल्ला है। जा के अपने के लिए हैं है से अपने के अपने के लिए के लिए के लिए के लिए हैं है है है है है है है है en aldronomie en 100 in en som kant en sombre disk med e godinan kom stig ge kontre å och sin sig til er britari ben sikali i kongrer militirang talggalakan ant balgan dagar sianti nake halo sikali er beaksike. rians, nie no do starie india eranie a anthematerian polando nie most a protog dinata alternia



- 1. Why is metal highly reflecting for incident electromagnetic wave?
- 2. How do you explain the following measured reflectivity spectrum of aluminum, which shows a drastic reduction of reflectivity for aluminum at ultraviolet wavelength range? (Taken from R. C. Vehse, E. T. Arakawa, and J. L. Stanford, Journal of Optical Society of America, 57, 551, 1967)
- 3. Could you provide a simple microscopic model for this?



Qualifying Exam 2011 Engineering Physics, Shanhui Fan

As a reminder, the time-dependent Schodinger equation of electrons:

$$i\hbar \frac{\partial \phi}{\partial t} = -\frac{\hbar^2}{2m} \frac{\partial^2 \phi}{\partial x^2} + V(x)\phi$$

and the time-independent Schodinger equation of electrons:

$$E\phi = -\frac{\hbar^2}{2m}\frac{\partial^2\phi}{\partial x^2} + V(x)\phi$$

(a) Suppose an electron is confined in an infinite potential well

$$V(x) = \begin{cases} 0, & 0 < x < a \\ \infty, & \text{everywhere else} \end{cases}$$

sketch the ground state $\phi_0(x)$ and the first excited state $\phi_1(x)$ for the electron in the potential well. Provide the eigen-energy of these two states.

(b) Suppose at t = 0, the electron has a wavefunction $\phi_0(x)$, what is the electron wavefunction at a time t later?

(c) Suppose at t = 0, the electron has a (un-normalized) wavefunction of $\phi_0(x) + \phi_1(x)$, could you sketch the shape of the electron probability density distribution as a function of time?

(d) Instead, consider the potential well:

$$V(x) = \begin{cases} \infty, x < 0 \\ 0, 0 < x < a \\ U > 0, a < x < a + b \\ 0, x > b \end{cases}$$

suppose at t = 0 the electron has a wavefunction $\phi_0(x)$, how does the probability of finding the electron in the potential well vary as a function of time?

Qualifying Exam 2013 EM, Shanhui Fan

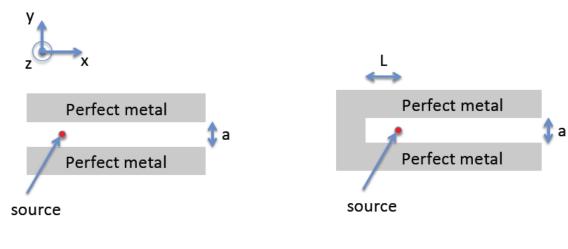


Figure 1 Figure 2

Consider a parallel-plate waveguide, with PEC (perfect electric conductor) sidewalls and air in between. The width of the waveguide is *a*. We consider two-dimensional system. (i.e. the fields and the structures are uniform in the *z*-direction).

- (1) Sketch the ω -k relation for the lowest-order TE mode (with E-field polarized along the z-direction), and for the lowest-order TM mode (with E-field polarized along the y-direction).
- (2) Suppose we put in an oscillating line source as indicated in Figure 1. The source oscillates at a frequency ω_0 . How does the power radiated into the waveguide changes as a function of ω_0 ? Consider both cases, the TE case with the line source polarized along the z-direction, and the TM case with the line source polarized along the y-direction.
- (3) Suppose we truncate the waveguide with a perfect electric conductor at the end as shown in Figure 2. For the TM case, suppose we choose $\omega_0 = 0.1 \frac{2\pi c}{a}$, how does the power radiated into the waveguide vary as a function of the distance L between the source and the truncation?