Phys 202

Final next Friday

8 questions
- 4 optics/wave eq'n
- 4 everything else

Review Optics 1st

- Geometric Optics
  - λ small compared to other geometric scale

light moves in rays

reflection — $\theta_1 = \theta_1'$

refraction — $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (Snell)

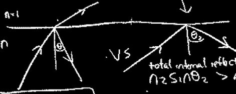
refraction cont'd

index of refraction

$n = c/v$ ← speed of light in medium

(frequency fixed, λ depends on n)

- total internal reflection



total internal reflection when $n_2 \sin\theta_2 > n_1$

§36 Image formation

mirrors + lenses

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \quad (1)$$

p ↑ distance to object; q ↑ distance to image; f ↑ focal length

Magnification

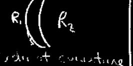
$$M = -\frac{q}{p} \quad (2)$$

(1) + (2) apply to mirrors and lenses

focal length

mirror $f = R/2$

thin lens



$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

convex (). concave)(

§37 Interference of light

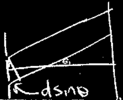
2-slit interference

constructive interference when

$$\delta\ (\text{path length difference}) = d\sin\theta_{bright} = m\lambda \quad (m=0,1,2,\ldots)$$

destructive interference when

$$d\sin\theta_{dark} = \left(m+\tfrac{1}{2}\right)\lambda \quad (m=0,1,2\ldots)$$



thin films:

recall: reflection off material with higher n gives π phase change

& reflect off material with lower n, no phase change

assume $n_f > 1$

$n_b > n_f$ constructive interference when $2n_f t = m\lambda$

$n_b < n_f$ constructive interference when $2n_f t = (m+\frac{1}{2})\lambda$ $m = 0, 1, 2, \ldots$

§38 Diffraction + polarization

Single slit Fraunhofer diffraction pattern: $I = I_{max}\left[\frac{\sin(\beta/2)}{\beta/2}\right]^2$

$\beta = (2\pi a \sin\theta/\lambda)$

diffraction limit: Rayleigh's criterion

$\theta_{min} = \lambda/a$

circular hole

$\theta_{min} = 1.22\,\lambda/D$

Diffraction grating

intensity maxima when

$$d \sin\theta_{bright} = m\lambda$$

resolving power

$$R = \frac{\lambda}{\Delta\lambda} \left(= \frac{(\lambda_1 + \lambda_2)/2}{\lambda_2 - \lambda_1} \right) = N m$$

N: # of slits; m: order of maximum

Polarization

if one polarization absorbed & other transmitted,

transmitted $I = I_{max} \cos^2\theta$;

polarization by reflection:

total polarization at Brewster's angle θ_p

$$\tan\theta_p = n$$

n = index of refraction of reflecting medium

- Electric charge
  - + − attract
  - same sign charges repel
  - conserved
  - quantized

Conductors

insulators

Coulomb's Law

$$\vec{F}_{12} = k \frac{q_1 q_2}{r^2} \hat{r}$$

Electric field: defined using force on test charge q_0:

$$\vec{E} = \vec{F}/q_0$$

principle of superposition:

$$\vec{E} = k \sum_i \frac{q_i}{r^2} \hat{r}$$

Electric flux

$$\Phi_E = \int_{\substack{\text{Surface}\\ A}} \vec{E} \cdot d\vec{A}$$

Gauss' law: electric flux through closed surface

$$\Phi_E = \oiint \vec{E} \cdot d\vec{A} = q_{enc}/\epsilon_0$$

Conductor:

$E = 0$ everywhere inside a conductor

electric field just outside a conductor is $\perp$ to surface. and has magnitude σ/ϵ_0

(σ = surface charge density)

Electric potential

$$\Delta U = -q_0 \int_A^B \vec{E} \cdot d\vec{s}$$

Change in potential energy when charge q_0 is moved from A to B

electric potential $V = U/q_0$

potential difference

$$\Delta V = \frac{\Delta U}{q_0} = -\int_A^B \vec{E}\cdot d\vec{s}$$

• capacitors ($Q = CV$)

dielectric

Series and parallel

energy stored in capacitor

Current + resistance

$$I = dQ/dt$$

dQ = charge passing through x-section in time dt

$$I = nqv_d A$$

Ohm's law

$$I = V/R$$

power dissipated

$$P = I\Delta V = I^2 R$$

Circuits

• Magnetism

magnetic force on moving charge

mag field generated by moving charges

Faraday's law

$$\mathcal{E} = -d\Phi_B/dt$$

Inductance

AC circuits

Electromagnetic Waves