

第二十章：光的波动性. (2003年 - 2017年)

选择题

①  $d \sin \theta = n \lambda$   
 $\frac{1 \div 1000}{500} \sin 17^\circ 10' = 1 \lambda$   
 $\lambda = 5.9 \times 10^{-7} \text{ m} \#$

C

②  $\lambda = \frac{a \Delta x}{D}$   
 $= \frac{(2 \div 1000) \times (3 \times 10^{-2} \div 100)}{}$   
 $= 6 \times 10^{-7} \text{ m} \#$

C

③ B

④  $r = \sqrt{m a \lambda}$   
 $8.62 \times 10^{-4} = \sqrt{4 \times (30 \div 100) \times \lambda}$   
 $\lambda = 8.19 \times 10^{-7} \text{ m} \#$

B.

⑤  $\lambda = \frac{a \Delta x}{D}$   
 $\frac{v}{f} = \frac{a \Delta x}{D}$   
 $\frac{300}{2000} = \frac{1.8 \times \Delta x}{10}$   
 $\Delta x = 0.833 \text{ m} \#$

B.

⑥  $n_{\text{空}} = \frac{a \times 0.6}{D}$        $n_{\text{液}} = \frac{a \times 0.5}{D}$

$$n = \frac{c}{v}$$

$$= \frac{f \lambda_{\text{空}}}{f \lambda_{\text{液}}}$$

$$= \frac{a \times 0.6}{a \times 0.5}$$

$$= 1.2$$

A

⑦  $r = \sqrt{m a \lambda}$   
 $= \sqrt{2 \times 0.5 \times 500 \times 10^{-9}}$   
 $= 7.07 \times 10^{-4} \text{ m} / 707 \mu\text{m}.$

D.

⑧ A

⑨ D

⑩ C

⑪ C

⑫  $r = \sqrt{m a \lambda}$   
 $\sqrt{m \times a \times 6 \times 10^{-7}} = \sqrt{(m+1) \times a \times 4.5 \times 10^{-7}}$   
 $6 \times 10^{-7} \text{ m} = 4.5 \times 10^{-7} \text{ m} + 4.5 \times 10^{-7} \text{ m}$   
 $m = 3 \#$  (第4个暗环)

B.

⑬  $2h = (m + \frac{1}{2}) \lambda$   
 $2 \times 2.7 \times 10^{-6} = (9 + \frac{1}{2}) \lambda$   
 $\lambda = 5.68 \times 10^{-7} \text{ m} \#$

C

⑭ D

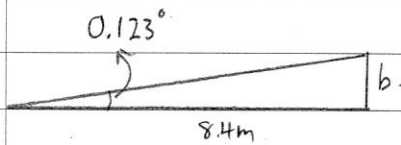
⑮  $n_x = \frac{a \Delta x_x}{D}$        $\frac{a}{D} = \frac{\lambda_y}{\Delta x_y}$   
 $\frac{a}{D} = \frac{\lambda_x}{\Delta x_x}$        $= \frac{\lambda_y}{x \div 3.5}$   
 $= \frac{\lambda_x}{x \div 3}$

$$\frac{3 \lambda_x}{x} = \frac{3.5 \lambda_y}{x}$$

$$\frac{\lambda_x}{\lambda_y} = \frac{7}{6} \#$$

D.

⑥  $d \sin \theta = m \lambda$   
 $0.28 \div 1000 \sin \theta = 1 \times 600 \times 10^{-9}$   
 $\theta = 0.123^\circ$



$\tan 0.123^\circ = \frac{b}{8.4}$   
 $b = 0.018 \text{ m} / 1.8 \text{ cm}$

C

作答题

1) (a) 同样是明暗相间的直线条纹, A 的中央亮纹的宽度及强度均比其他的亮纹大很多, B 的中央亮纹比其他的亮纹较亮但宽度差不多。

(b) 衍射 ; 干涉

(c) (i)  $\lambda = \frac{a \Delta x}{D}$   
 $= \frac{2.5 \times 10^{-4} \times (13 \div 1000 \div 2.5)}{2}$   
 $= 6.5 \times 10^{-7} \text{ m}$

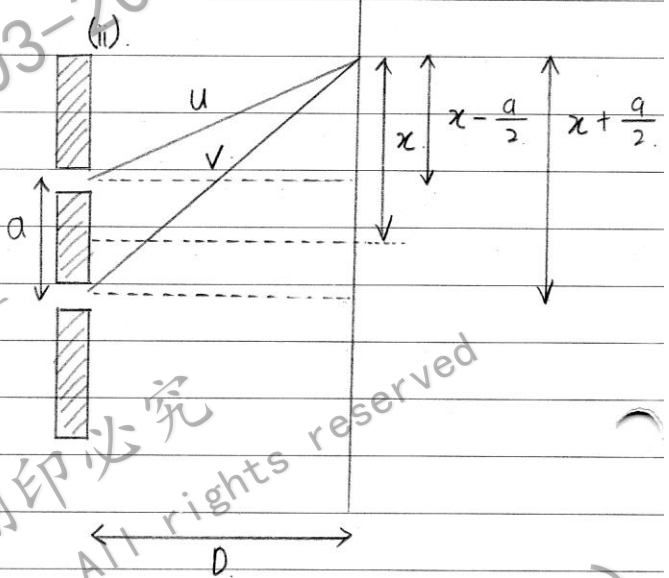
(ii) 第一条暗纹与第三条暗纹的间距  
 $= 13 \div 2.5 \times 2$   
 $= 10.4 \text{ mm}$

(ii)  $26 \text{ mm} \div (13 \text{ mm} \div 2.5) = 5$   
 $\therefore$  亮纹的第 5 级别。

2) (i) 相邻亮纹的间距  $= 2.4 \text{ mm} \div 4$   
 $= 0.6 \text{ mm}$

(ii)  $\lambda = \frac{a \Delta x}{D}$   
 $= \frac{(0.6 \div 1000) \times (0.6 \div 1000)}{1}$   
 $= 3.6 \times 10^{-7} \text{ m}$

③ (a) (i) 频率相同, 振动方向一致, 振幅相同, 位差在一段时间间隔内保持不变。



$v^2 - u^2 = [D^2 + (x + \frac{a}{2})^2] - [D^2 + (x - \frac{a}{2})^2]$   
 $v^2 - u^2 = D^2 + x^2 + ax + \frac{a^2}{4} - D^2 - x^2 + ax - \frac{a^2}{4}$   
 $v^2 - u^2 = 2ax$

$(v-u)(v+u) = 2ax$        $D \gg a$

$\delta(2b) = 2ax$   
 $\delta = \frac{ax}{D}$

(b) (i)  $\lambda = \frac{ax}{D}$   
 $200 \times 10^{-9} = \frac{a \times (2 \div 100)}{D}$   
 $\frac{a}{D} = 1 \times 10^{-5}$

$\lambda = \frac{ax}{D}$   
 $550 \times 10^{-9} = 1 \times 10^{-5} x$   
 $x = 0.055 \text{ m} / 5.5 \text{ cm}$

(ii)  $\lambda = \frac{ax}{D}$   
 $200 \times 10^{-9} = \frac{a}{D} \times 0.02 \times \frac{110}{100}$   
 $\frac{a}{D} = 9.09 \times 10^{-6}$

将光屏与双缝的距离比例调至  $9.09 \times 10^6$

$$(iii) \lambda_a = \frac{a \Delta x_a}{D} \quad \lambda_w = \frac{a \Delta x_w}{D}$$

$$n_w = \frac{c}{v}$$

$$n_w = \frac{f \lambda_a}{f \lambda_w}$$

$$n_w = \frac{a \Delta x_a}{a \Delta x_w}$$

$$n_w = \frac{\Delta x_a}{\Delta x_w} \#$$

$\therefore$  即中央亮纹宽度是原来的  $n_w$  倍。

$$(4) (a)(i) \quad d \sin \theta = m \lambda$$

$$\frac{1 \div 1000}{410} \sin \theta_1 = 1 \times 410 \times 10^{-9}$$

$$\theta_1 = 9.68^\circ$$

$$d \sin \theta = m \lambda$$

$$\frac{1 \div 1000}{410} \sin \theta_2 = 1 \times 434 \times 10^{-9}$$

$$\theta_2 = 10.25^\circ$$

$$\theta_2 - \theta_1 = 10.25^\circ - 9.68^\circ = 0.57^\circ \#$$

$$(ii) \lambda_1: d \sin \theta = m \lambda$$

$$\sin \theta = \frac{m \lambda}{d} \quad \theta_{\max} = 90^\circ$$

$$1 = \frac{m \times 410 \times 10^{-9}}{1 \div 1000 \div 410}$$

$$m_1 = 5.9$$

$$\lambda_2: \sin \theta = \frac{m \lambda}{d} \quad \theta_{\max} = 90^\circ$$

$$1 = \frac{m \times 434 \times 10^{-9}}{1 \div 1000 \div 410}$$

$$m = 5.6$$

$\therefore \lambda_1$  的波长可得到 11 条亮纹条纹。

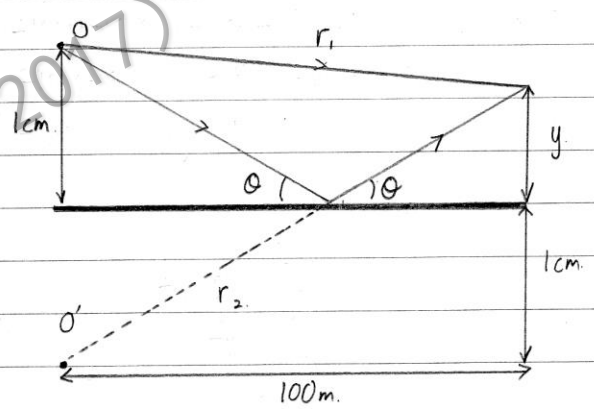
$\lambda_2$  的波长可得到 11 条亮纹条纹。

(b) 光源 O 经平面镜反射后, 得一虚像 O'。O 与 O' 可视为两相干性光源。

$\therefore$  反射光的相位与入射光的光程差 =

$$(r_2 - r_1) + \frac{\lambda}{2}$$

根据杨氏双缝, 产生暗纹条件, 光程差 =  $(m + \frac{1}{2}) \lambda$ 。



$$r_1^2 = l^2 + (0.01 - y)^2 \quad r_2^2 = l^2 + (0.01 + y)^2$$

$$r_2^2 - r_1^2 = l^2 + (0.01 + y)^2 - [l^2 + (0.01 - y)^2]$$

$$(r_2 - r_1)(r_2 + r_1) = l + 0.01^2 + 0.02y + y^2 - (l + 0.01^2 - 0.02y + y^2)$$

$$(r_2 - r_1)(200) = 0.04y$$

$$r_2 - r_1 = 2 \times 10^{-4} y$$

$$(r_2 - r_1) + \frac{\lambda}{2} = (m + \frac{1}{2}) \lambda \quad ; m = 1$$

$$2 \times 10^{-4} y + \frac{\lambda}{2} = \frac{3}{2} \lambda$$

$$2 \times 10^{-4} y = 500 \times 10^{-9}$$

$$y = 2.5 \times 10^{-3} \text{ m} \#$$

$$(c)(i) \quad d \sin \theta = m \lambda$$

$$0.75 \div 1000 \sin \theta = 1 \times 587.5 \times 10^{-9}$$

$$\theta = 0.045^\circ$$

$$\tan \theta = \frac{y}{D}$$

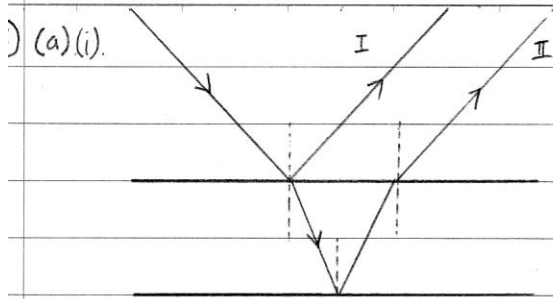
$$\tan 0.045^\circ = \frac{0.85 \div 1000}{D}$$

$$D = 1.085 \text{ m} \#$$

$$(ii) \text{ 中央亮纹的宽度} = 2y_1$$

$$= 2 \times 0.85 \times 10^{-3}$$

$$= 1.7 \times 10^{-3} \text{ m} / 1.7 \text{ mm} \#$$



当一列光波照射到透明薄膜上,从膜的前后表面分别反射形成 I, II 两列相干光波,叠加产生干涉。

$$(ii) \quad 2d = (m + \frac{1}{2})\lambda$$

$$2\lambda = (19 + \frac{1}{2}) \times 434 \times 10^{-9}$$

$$\lambda = 4.23 \times 10^{-6} \text{ m} \#$$

$$(b)(i) \quad d \sin \theta = m\lambda$$

$$\frac{1}{6 \times 10^5} \sin \theta_r = 1 \times 700 \times 10^{-9}$$

$$\theta_r = 24.83^\circ$$

$$d \sin \theta = m\lambda$$

$$\frac{1}{6 \times 10^5} \sin \theta_b = 1 \times 400 \times 10^{-9}$$

$$\theta_b = 13.89^\circ$$

$$(ii) \quad d \sin \theta = m\lambda$$

$$\frac{1}{6 \times 10^5} \sin \theta_r = 2 \times 700 \times 10^{-9}$$

$$\theta_r = 57.14^\circ$$

$$d \sin \theta = m\lambda$$

$$\frac{1}{6 \times 10^5} \sin \theta_b = 2 \times 400 \times 10^{-9}$$

$$\theta_b = 28.69^\circ \#$$

$$(iii) \quad \frac{\alpha}{\beta} = \frac{24.83 - 13.89}{57.14 - 28.69}$$

$$= 0.38 \#$$

$$(6)(a) \quad d \sin \theta = m\lambda$$

$$\frac{1 \div 1000}{180} \sin \theta_1 = 2 \times 400 \times 10^{-9}$$

$$\theta_1 = 8.28^\circ$$

$$d \sin \theta = m\lambda$$

$$\frac{1 \div 1000}{180} \sin \theta_2 = 2 \times 500 \times 10^{-9}$$

$$\theta_2 = 10.37^\circ$$

$\therefore$  两个衍射波的第二级明条纹相隔的角度

$$= 10.37^\circ - 8.28^\circ$$

$$= 2.09^\circ \#$$

$$(b)(i) \quad d \sin \theta = m\lambda$$

$$d \sin 90 = 4 \times 450 \times 10^{-9}$$

$$d = 1.8 \times 10^{-6} \text{ m}$$

$$d \sin \theta = m\lambda$$

$$1.8 \times 10^{-6} \sin 90 = 3 \times \lambda$$

$$\lambda = 6 \times 10^{-7} \#$$

$\therefore$  当  $600 \text{ nm} < \lambda < 700 \text{ nm}$ , 不会出现在第三条纹中。

$$(ii) \quad d \sin \theta = m\lambda$$

$$d \sin 90 = 4 \times 400 \times 10^{-9}$$

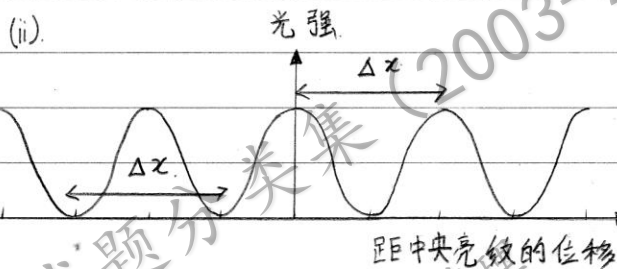
$$d = 1.6 \times 10^{-6} \text{ m}$$

$$\Delta d = 1.8 \times 10^{-6} - 1.6 \times 10^{-6} \text{ m}$$

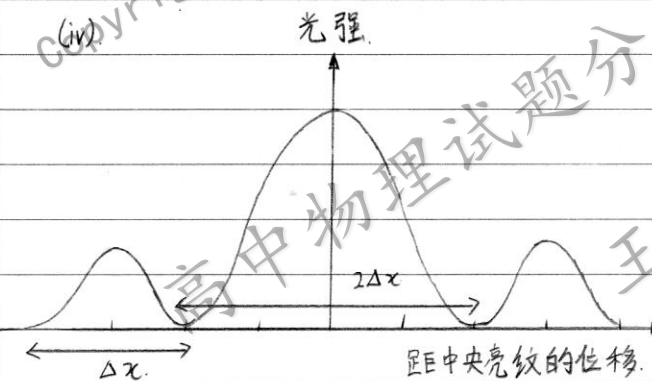
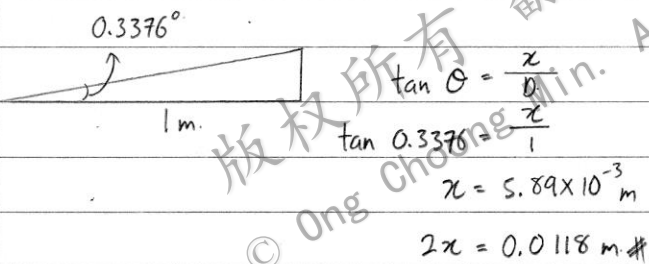
$$= 2 \times 10^{-7} \text{ m} / 200 \text{ nm} \text{ (缩小)}$$

(7)(a) 将 S 置于双缝  $S_1$  与  $S_2$  的中垂线上, 由于传到双缝的光都是来自同一个光源, 它们的频率与振幅是一样的, 且  $SS_1$  的距离与  $SS_2$  的距离一样, 因此由 S 传到  $S_1$  与  $S_2$  的光波一定会同相位。

(b)(i)  $\lambda = \frac{a \Delta x}{D}$   
 $589.3 \times 10^{-9} = \frac{800 \times 10^{-6} \Delta x}{1}$   
 $\Delta x = 7.37 \times 10^{-4} \text{ m} / 0.74 \text{ mm} \#$



(iii)  $d \sin \theta = n \lambda$   
 $0.1 \div 1000 \sin \theta = 1 \times 589.3 \times 10^{-9}$   
 $\theta = 0.3376^\circ$



⑧ (i)  $\lambda = \frac{a \Delta x}{D}$   
 $= \frac{(0.56 \div 1000) \times (3.6 \div 1000 \div 4)}{0.8}$   
 $= 6.3 \times 10^{-7} \text{ m} / 630 \text{ nm} \#$

(ii) 亮条纹的间距变大, 亮度较弱.

⑨ (i)  $r_1^2 = D^2 + (x - \frac{a}{2})^2$   $r_2^2 = D^2 + (x + \frac{a}{2})^2$   
 $r_2^2 - r_1^2 = D^2 + (x + \frac{a}{2})^2 - D^2 - (x - \frac{a}{2})^2$   
 $(r_2 - r_1)(r_2 + r_1) = x^2 + ax + \frac{a^2}{4} - (x^2 - ax + \frac{a^2}{4})$   
 $(r_2 - r_1) \times 2D = 2ax$   
 $\delta = \frac{ax}{D} \#$

(ii) 亮纹:  $\delta = m \lambda$ ;  $m = 0, 1, 2, 3, \dots$   
 暗纹:  $\delta = (m + \frac{1}{2}) \lambda$ ;  $m = 0, 1, 2, \dots$

(iii) 黄光:  $\lambda = \frac{a \Delta x}{D}$   
 $5.5 \times 10^{-7} = \frac{a(0.275 \div 1000)}{D}$   
 $\frac{a}{D} = 2 \times 10^{-3}$

紫光:  $\frac{ax}{D} = m \lambda$   
 $2 \times 10^{-3} x = 1 \times 4 \times 10^{-7}$   
 $x = 2 \times 10^{-4} \text{ m}$

橙光:  $\frac{ax}{D} = m \lambda$   
 $2 \times 10^{-3} x = 1 \times 6 \times 10^{-7}$   
 $x = 3 \times 10^{-4} \text{ m}$

$\therefore$  紫光和橙光第一级亮纹间的距离  
 $= 3 \times 10^{-4} \text{ m} - 2 \times 10^{-4} \text{ m}$   
 $= 1 \times 10^{-4} \text{ m} / 0.1 \text{ mm} \#$

⑩ (i)  $\delta = \frac{ax}{D}$   
 $= \frac{(0.15 \div 1000)(1.92 \div 100)}{1.5}$   
 $= 1.92 \times 10^{-6} \text{ m} / 3 \lambda \#$

(ii) 第3级亮纹

$$\textcircled{11} \quad \lambda = \frac{a \Delta z}{D}$$

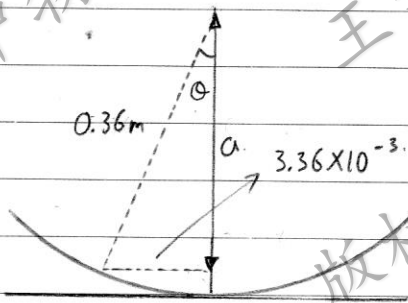
$$\frac{3 \times 10^6}{f} = \frac{(1.2 \div 1000) \times (2 \div 100 \div 4)}{1}$$

$$f = 5 \times 10^{13} \text{ Hz}$$

$$\textcircled{12} \quad r = \sqrt{m a \lambda}$$

$$= \sqrt{49 \times 38 \div 100 \times 6.4 \times 10^{-7}}$$

$$= 3.36 \times 10^{-3} \text{ m}$$



$$0.36^2 = (3.36 \times 10^{-3})^2 + a^2$$

$$a = 0.35998 \text{ m}$$

$$h = 0.36 \text{ m} - 0.35998 \text{ m}$$

$$= 1.57 \times 10^{-5} \text{ m}$$

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