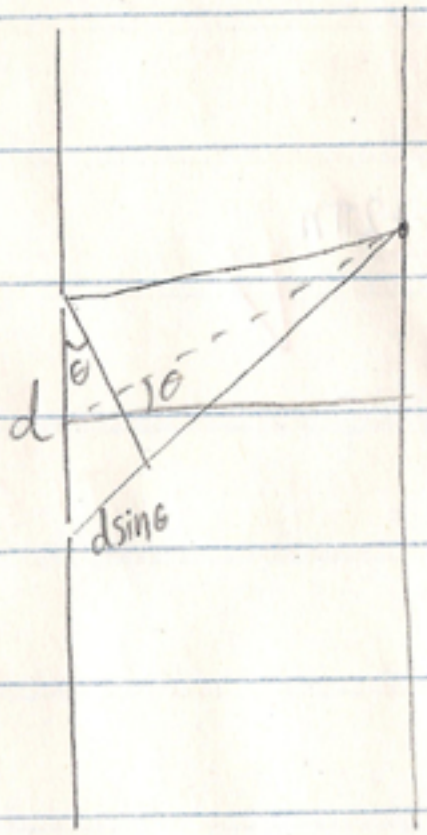
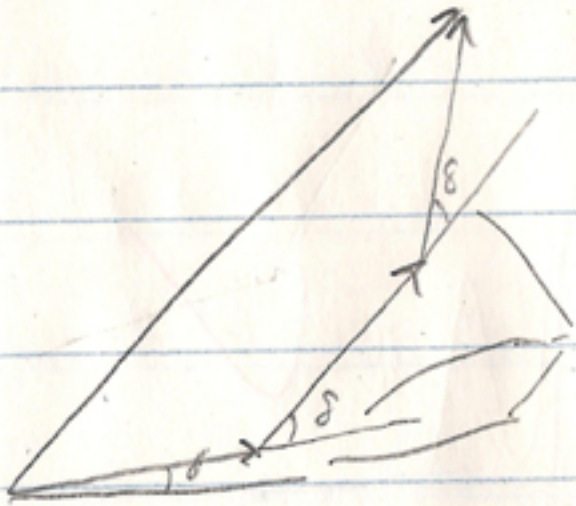
1)

a)



$$\frac{\delta}{2\pi} = \frac{d\sin\theta}{\lambda} \Rightarrow \boxed{\delta = \frac{2\pi d\sin\theta}{\lambda}}$$

b)



Length of each vector = $\frac{E_0}{3}$ Since the amplitude is divide equally

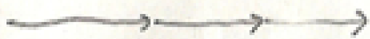
Length of resulting vector is the amplitude of the three slits added together

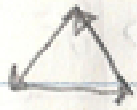
Angle of vector is 3δ

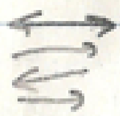
$v = 1$ max $\frac{3}{3}$

$v = 1.5$ semimax $\frac{1.5}{3}$

$1.33 = $ min $\frac{4}{3}$

c) I)  $\delta = 2\pi n$

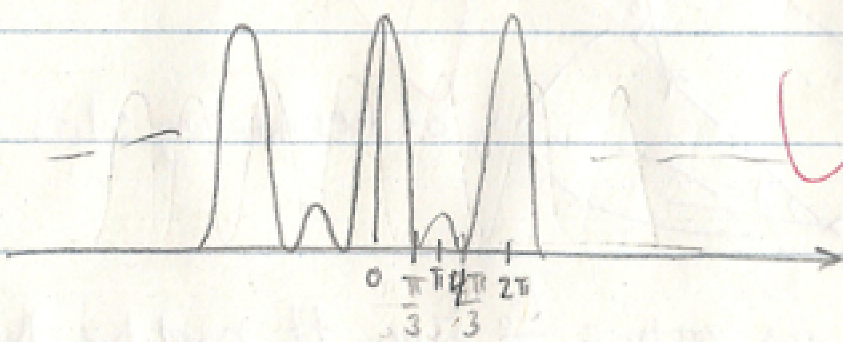
II)  $\delta = \frac{\pi}{3} + 2\pi n, \ \frac{4\pi}{3} + 2\pi n$ ✓

III)  $\delta = \pi + 2\pi n$

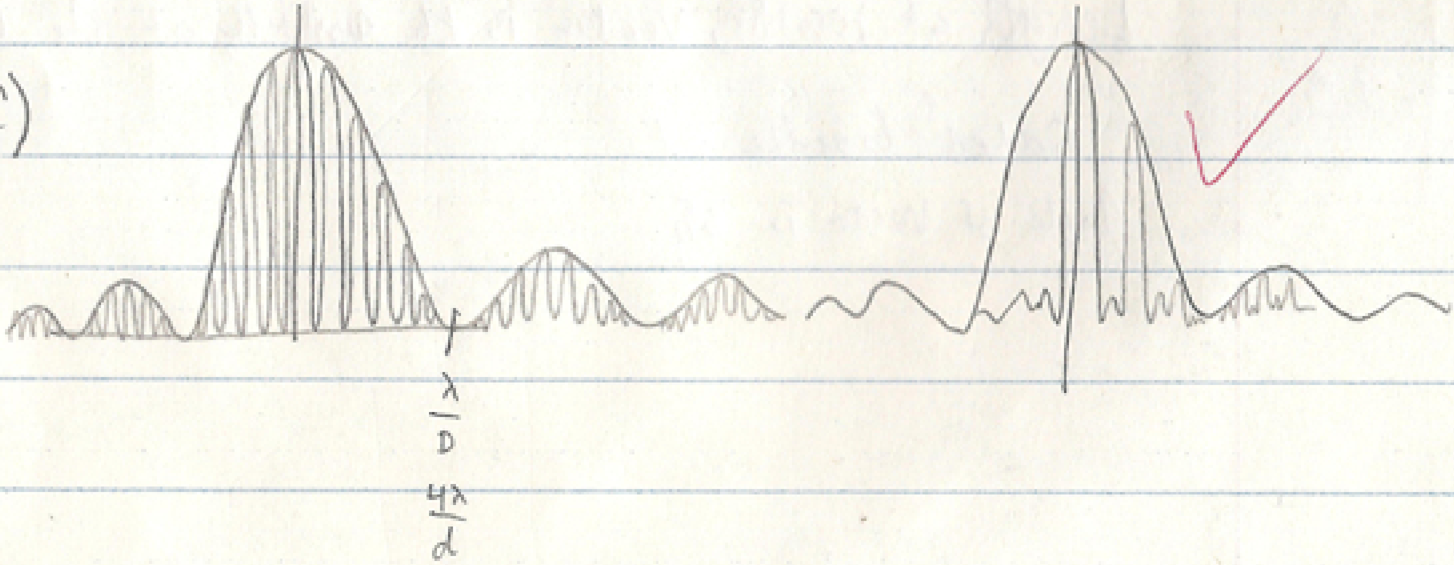
d) I) 1

II) 0

III) $\frac{1}{3}$ ✓

e) 

✓ 1

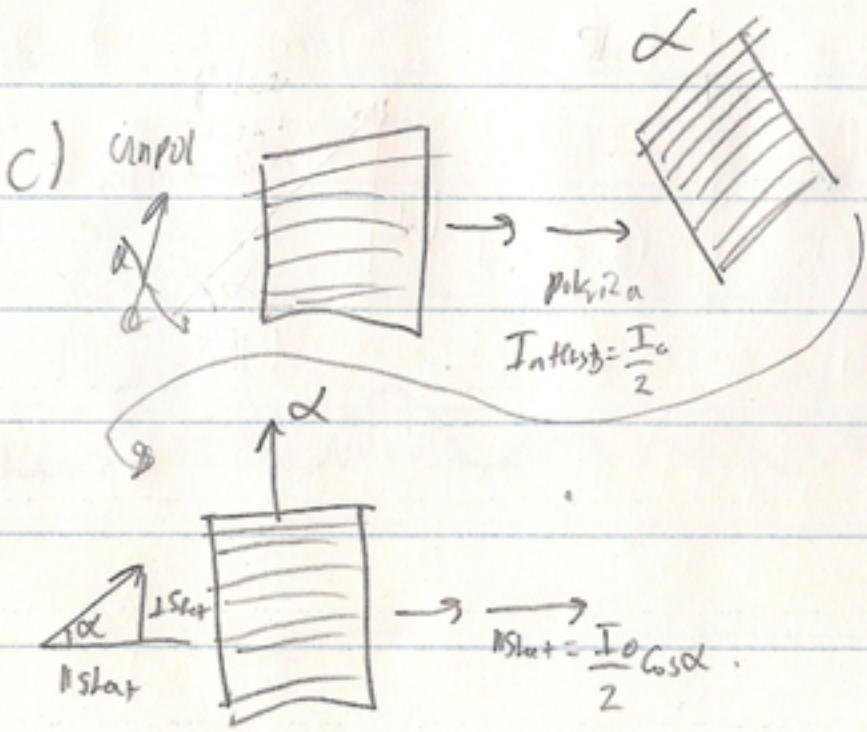
f) 

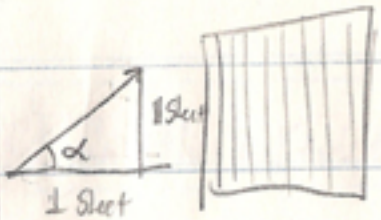
✓

2) a) Intensity is $\frac{I}{2}$ since only about half the light is polarized in that direction +3

b) Intensity is 0 since the light coming out of the first sheet is only polarized +2 in the $\hat{y}$ direction, which is orthogonal to the $\hat{x}$ direction, so no $\hat{x}$ component is in the light. Therefore, when the $\hat{x}$ polarizer hits the light, it lets none of the intensity out.

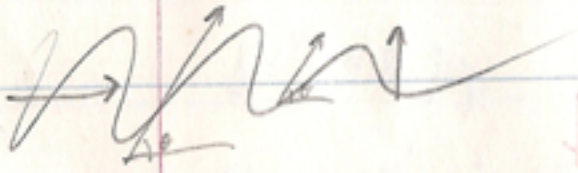
c)



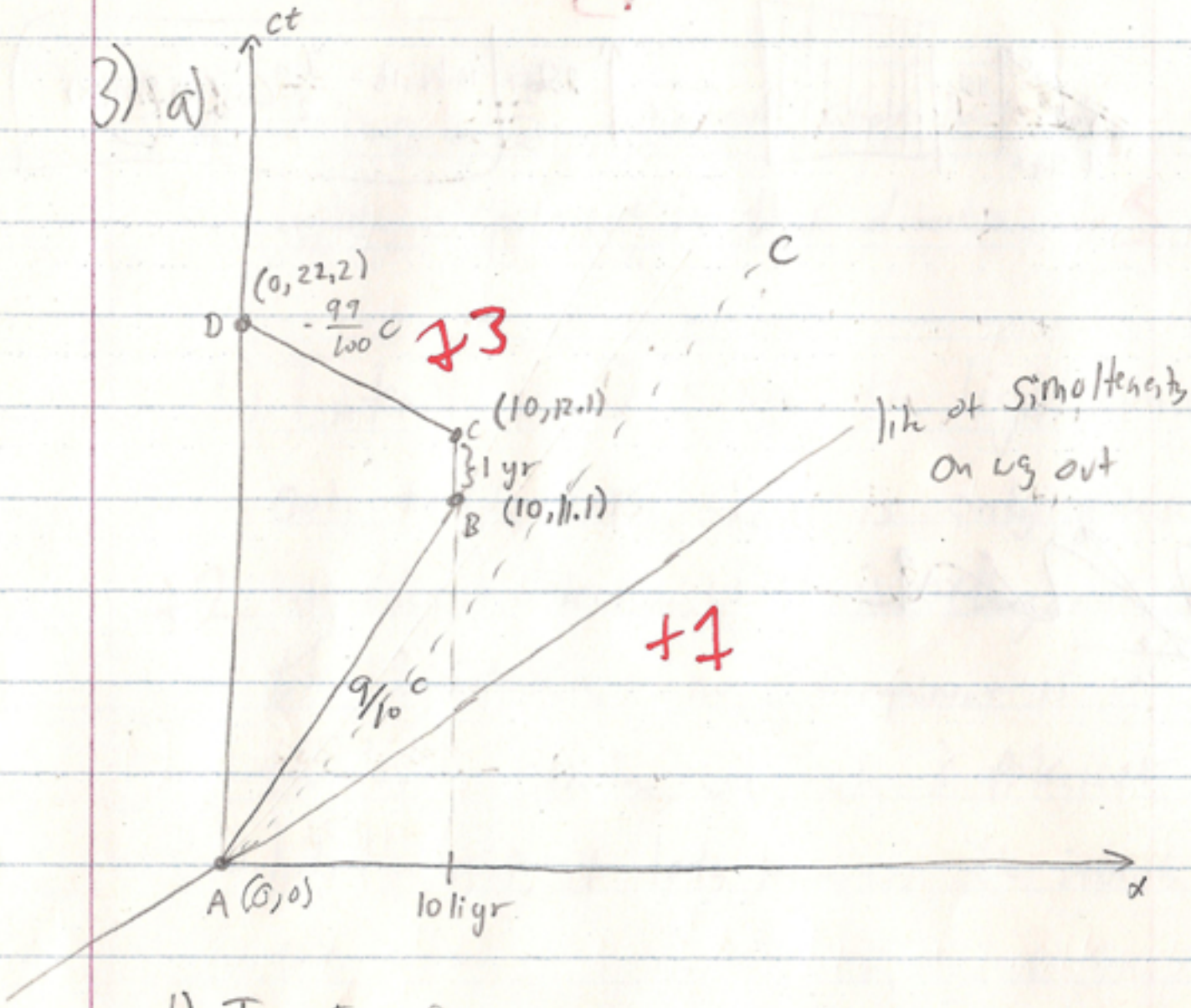


→ ↑ 1 Sheet

$$\text{intensity} = \frac{I_0}{2}\cos(\alpha)\sin(\alpha)$$



3) a)



b) In Earth-Star frame: dist(A,B) = 10 light years

+4

$$\text{time}(A,B) = \frac{10c}{\frac{9}{10}c} = 11.1 \text{ yrs}$$

dist (C,D) = 10 light yrs

$$\text{time}(C,D) = \frac{10c}{\frac{99}{100}c} = 10.1 \text{ yrs}$$

Her mom saw the trip taking $11.1 + 1 + 10.1 = 22.2$ yrs

A = (0,0)

B = (10, 11.1)

C = (10, 12.1)

D = (0, 22.2)

c) In Alice's rest frame: $\gamma = \frac{1}{\sqrt{1-(\frac{9}{10})^2}} = 2.29$ $\beta = \frac{9}{10}$

+5

$A = (0,0)$

$B_t = \gamma(10 - \beta \cdot 11.1) = .023$

$B_x = \gamma(-\beta \cdot 10 + 11.1) = 4.82$

$\Delta t' = .023$ yr

$\Delta x' = 4.82$ liyr

Check: $\Delta I_{interval}^2 = \Delta x'^2 - \Delta t'^2 = 4.82^2 - .023^2 \approx 23.21$

$= \Delta x^2 - \Delta t^2 = 11.1^2 - 10^2 \approx 23.21$ ✓

d) Time interval for (B,C) = 1 yr since she traveled no distance in that time

+3

Tim interval fr (C,D) = τ $\tau^2 = \Delta t^2 - \Delta x^2 = 10.1^2 - 10^2 = 2.01$

$\tau = \sqrt{2.01} = 1.42$ yrs

Trip took $4.82 + 1 + 1.42 = 7.24$ yrs according to Alice

e) Alice is 7.24 yrs older, She is 27.24 yrs old

+4 When she decelerated to land on the planet, and when she accelerated to cruising speed on her return, she had to get out of her inertial reference frame, so there is no paradox since her frame was not inertial.

f) $t' = \frac{t - \frac{vx}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}} = \text{Constant}$

+1

$0 = t - \frac{9}{10}x \Rightarrow t = \frac{9}{10}x$ line of simultaneity

g) length contraction $L' = \frac{L}{\gamma} = 10\,\text{ligyr}\left(\sqrt{1 - \left(\frac{9}{10}\right)^2}\right) = 4.36\ \text{li gr}$

+4

Velocity addition: $\frac{v+u}{1 + \frac{vu}{c^2}}$ An $v = \frac{9}{10}c$, $u = 0 \Rightarrow$ star velocity $= \frac{9}{10}c$

$\frac{L'}{\text{star velocity}} \approx 4.82$ yrs, same as c)